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ENVIRONMENTAL MONITORING PLAN OUTLINE

GEOKINETICS SEEP RIDGE PROJECT

UINTAH COUNTY, UTAH

047/002

Presented to

United States Synthetic Fuels Corporation

August 1983

By

Geokinetics, Inc.
Salt Lake City, Utah

Prepared by

VTN Consolidated, Inc.
Irvine, California

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SECTION 1.0

INTRODUCTION

Geokinetics, a corporation that pioneered an in-situ oil shale retorting process, is presently applying for financial assistance for its Seep Ridge Project from the U.S. Synthetic Fuels Corporation (SFC). Financial assistance from the SFC is contingent upon meeting many requirements, including compliance with Section 131e of the Energy Security Act which states, in part:

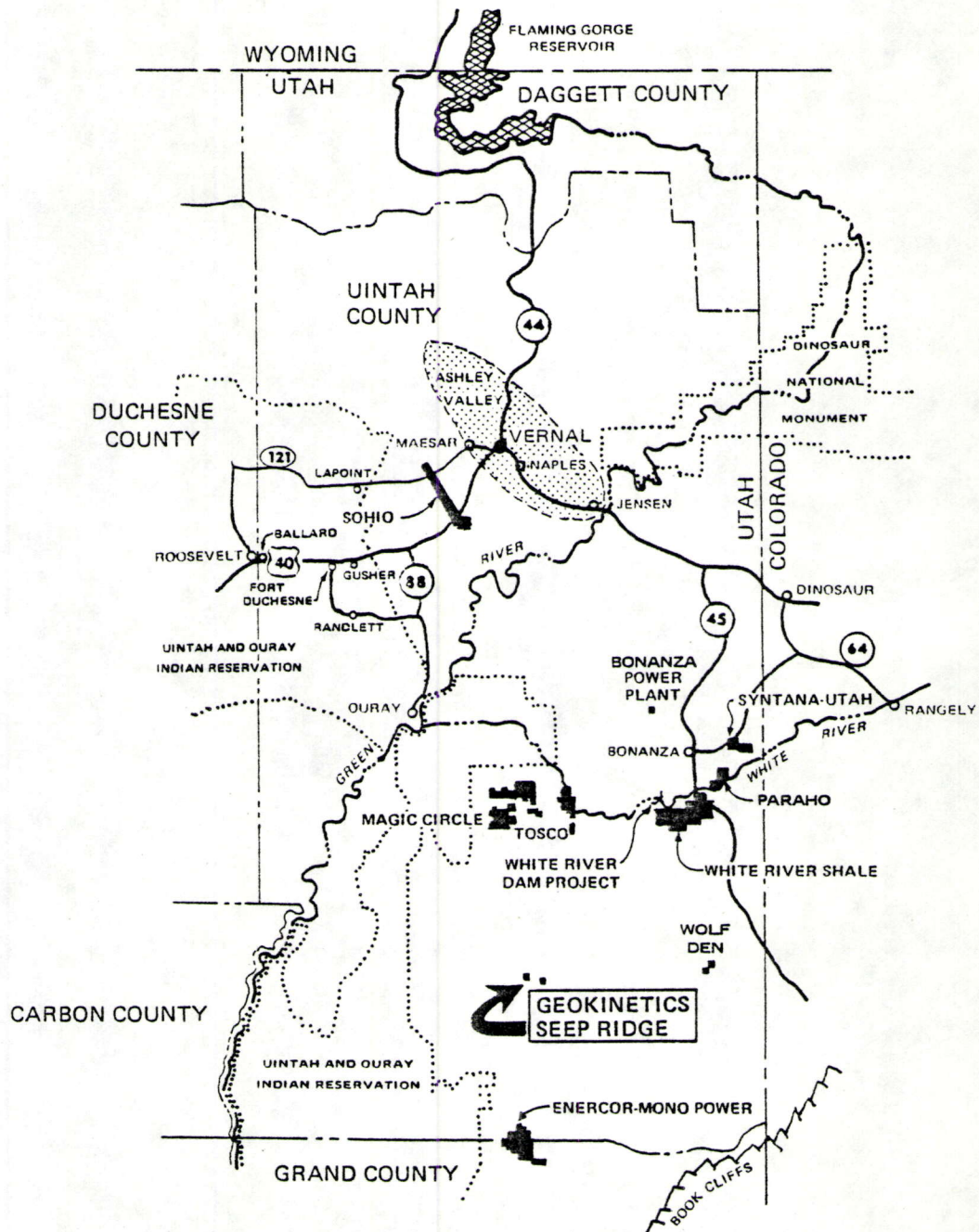
"Any...financial assistance shall require development of a plan... for monitoring of environmental and health-related emissions from the construction and operation of [a] synthetic fuels project. Such a plan shall be developed...after consultation with the administrator of the Environmental Protection Agency, the Secretary of Energy and appropriate state agencies."

On July 28, 1983, the SFC issued final environmental monitoring guidelines which were designed to carry out the provisions of Section 131e and proposed the development of monitoring plans in two stages: i) development of a monitoring plan outline for incorporation into the financial assistance contract and ii) development of the final monitoring plan immediately following contract finalization.

In response to the above guidelines, Geokinetics has prepared a monitoring plan outline that describes the ambient, source, and health and safety monitoring activities planned for its Seep Ridge Project.

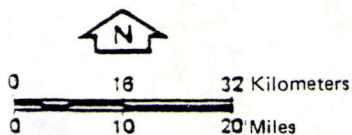
1.1 Project Description

The Seep Ridge project is situated in Uintah County, approximately 70 miles south of the City of Vernal, Utah (Figure 1-1). Figure 1-2 is a site location map showing the land involved, which includes the Seep Ridge Tract in Section 2, Township 14 South, Range 22 East and the Woods Canyon tract in Section 32, Township 13 South, Range 22 East.

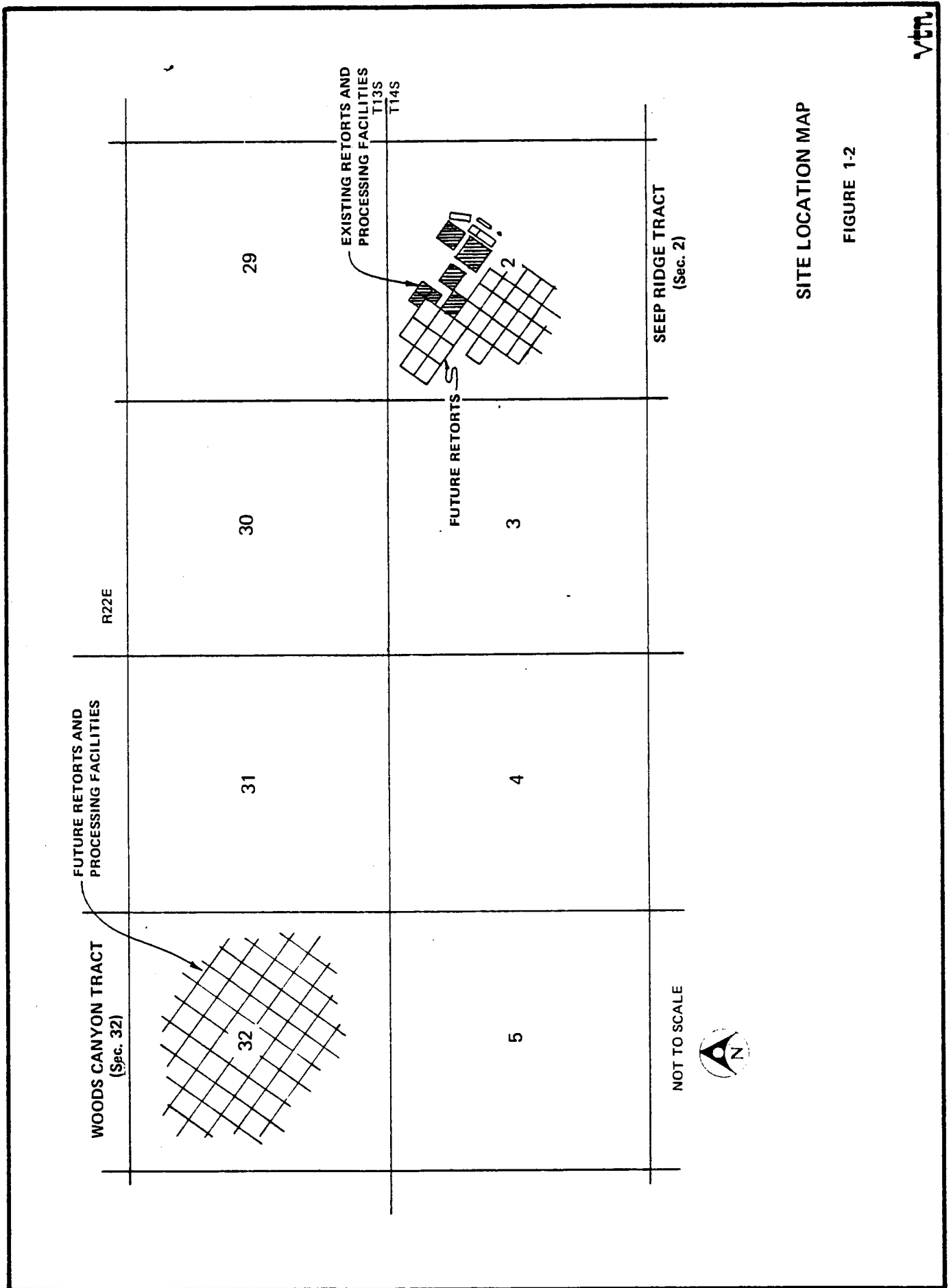


SEEP RIDGE PROJECT
REGIONAL PROJECT LOCATION MAP

FIGURE 1-1



VTT



SITE LOCATION MAP

FIGURE 1-2

Project design currently calls for a series of seven in-situ retorts, to be operated simultaneously. While seven retorts are producing shale oil, an additional seven retorts will be in various stages of construction. As the first series of retorts is depleted of shale oil, the equipment will be dismantled and moved to new retorts undergoing construction. The surface of the old retorts will be reclaimed with stored topsoil and native vegetation. Thus, as retorts continue operation, new sets of retorts will be put on stream while others are undergoing construction or reclamation. Hence, construction, operation and reclamation activities will occur continuously.

Each in-situ retort has a surface area of two and one-half acres, making the total size of the seven-retort set, including above-ground equipment, approximately 25 acres. Above-ground facilities include oil storage, retort water treatment, waste transfer, ammonia and sulfur removal, gas incineration and power generation facilities. A detailed description of the above-ground processes is presented in Section 2.0.

1.2 Ambient, Source and Health and Safety Monitoring Programs

The monitoring plan outline prepared by Geokinetics is based on SFC guidelines and ambient/source monitoring references prepared by the EPA. The monitoring plan is composed of three programs: ambient, source and occupational health and safety. Each program is characterized by a phased approach wherein potential monitoring parameters are screened for usefulness in Phase I using survey analytical techniques. The results from Phase I will redirect monitoring toward useful and informative parameters that are to be identified included in Phase II "routine" analysis. Hence, Phase I is a screening process to identify important parameters that reflect environmental conditions to be used in the Phase II, "routine" monitoring program. Generally, Phase I will be conducted to correspond roughly with operation of the first set of seven retorts. Phase II monitoring will generally be conducted thereafter until all construction, retorting, processing, and post-operation

activities are concluded. Figure 1-3 shows a preliminary schedule of monitoring activities through the life of the project. This proposed schedule will require some flexibility with respect to the initiation of Phase II after Phase I monitoring is completed. While it is expected that Phase II will commence as scheduled, Phase I monitoring may be conducted beyond the indicated periods.

Ambient Monitoring

Monitoring of the ambient environment (air quality, meteorology, hydrology and water quality, vegetation, wildlife and soils) will be conducted throughout the life of the project. During preconstruction, construction, operation and post-operation of the first seven retorts, Phase I monitoring will be conducted. After that period, Phase II monitoring will be conducted and continue for the duration of all construction, retorting and processing activities. Hence, from the second year through the operation of the last set of seven retorts (scheduled to be 10 years), Phase II or "routine" monitoring will be regularly conducted (Figure 1-3). Section 3.0 presents the Ambient Monitoring Program outline.

Source Monitoring

Source monitoring will begin with the construction and operation of the first seven retorts. The Phase I monitoring (screening period) for solid, liquid and gaseous emissions will be conducted from the initiation of construction activities through to the conclusion of the retorting/processing activities associated with those retorts. Phase II monitoring for emissions will occur during subsequent construction and retorting/processing activities associated with each seven-retort set (Figure 1-3).

The source monitoring program will monitor for both regulated and unregulated pollutants. Regulated pollutants, those substances that

FIGURE 1-3
MONITORING SCHEDULE ⁽¹⁾

PHASE	RETORT SET	AMBIENT MONITORING	SOURCE MONITORING	HEALTH AND SAFETY MONITORING
I	1 P C O P/O	• • •	• •	• • •
II	2 P C O P/O	• • •	• •	• • •
II	3 P C O P/O	• • •	• •	• • •
II	4 P C O P/O	• • •	• •	• • •
II	5 P C O P/O	• • •	• •	• • •
II	6 P C O P/O	• • •	• •	• • •
II	7 P C O P/O	• • •	• •	• • •
II	8 P C O P/O	• • •	• •	• • •
II	9 P C O P/O	• • •	• •	• • •
II	10 P C O P/O	• • •	• •	• • •

P = PRECONSTRUCTION
C = CONSTRUCTION
O = OPERATION
P/O = POST-OPERATION

(1) SCHEDULE IS PRELIMINARY AND WILL
DEPEND ON RESULTS OF PHASE I ANALYSIS

VCH

are of concern to regulatory agencies because of legal requirements, will be monitored in the "compliance" portion of the source monitoring program. Unregulated pollutants, "those substances not presently regulated under any law and those which may be regulated under one law and not another," will be monitored under the supplemental monitoring program. The specific monitoring routines and protocols of the Source Monitoring Program are presented in Section 4.0.

Health and Safety Monitoring

Health and safety monitoring for emissions potentially affecting the worker environment is addressed in Section 5.0. During the first complete cycle of operation (construction, operation and post-operation) where worker health may be affected, Phase I monitoring will be conducted. After data characterizing the worker health from Phase I monitoring have been analyzed, the Phase II routine program will be initiated. Much of the data involved in health and safety monitoring will be generated in the Source Monitoring Program.

1.3 Program Components

Each monitoring program will include a description of program design defining the assumptions and concerns which guided monitoring program development. Program design and rationale for each program is based on the identification of probable impacts from project development. While it is obvious that a monitoring program is designed to detect changes and quantify environmental effects that occur, some programs may emphasize specific objectives or predicted impacts. For example, ground water monitoring to detect any potential movement of materials through the underground retorts is one objective of the monitoring effort.

In addition, monitoring parameters to be measured, descriptions of monitoring methods, and monitoring locations will be defined. These sections will indicate the way in which sample methods and sites were

chosen and describe the sampling plan in terms of temporal or physical/chemical conditions.

Quality Assurance/Quality Control (QA/QC)

This section will define the QA and QC procedures used in the monitoring plan. Geokinetics will employ QA/QC methods that are appropriate to the oil shale industry and/or are acceptable to the EPA or state agencies. Generally, Geokinetics will periodically check procedures associated with sample collection, data analysis, data storage/retrieval and report generation. Laboratory and field instruments will be calibrated.

As a check on data accuracy/reliability, standard methods for collection and analysis of samples will be required. In instances where an outside laboratory is utilized, approved QA procedures and EPA-approved methodologies will be utilized.

As part of the QA/QC program, Geokinetics will periodically review the quality control program to verify results of analyses. These reviews will be in the form of audits and surveillances which will cover procedures utilized on all project work. The results of the audits and surveillances will be reported in audit reports that will be issued at regular intervals.

Geokinetics will maintain project records containing original data and transmittals. The access and use of these records will be controlled by written procedures for document control and data management.

Data Management

Implementation of a monitoring plan such as the one proposed for Geokinetics will generate large amounts of data. These data must be accurately recorded for later use in analysis of environmental control,

project effects and worker health. These analyses require that data from the ambient, source, and health and safety monitoring programs be accessible for cross-correlation. For example, data on emissions measured in the source program should be meaningfully evaluated in the health and safety program relative to worker health, and be assessed for impacts relative to local ambient conditions. Thus, careful and accurate data/record-keeping is essential. A detailed plan for data management will be developed for the final monitoring plan.

Report Submittal

Geokinetics will make provisions to submit quarterly reports that document:

- o Environmental and health monitoring results recorded during the previous quarter.
- o Permit status and compliance monitoring tasks.
- o Significant trends and potential problem areas should any become apparent.
- o Recommendations for plan modification based on data analysis.

Annual reports will contain the fourth quarterly report for the year. This report will also include the previous three quarterly reports and the last quarterly report from the previous year. Significant trends will be summarized and results of monitoring for unregulated substances will be discussed.

SECTION 2.0

PROCESS DESCRIPTION

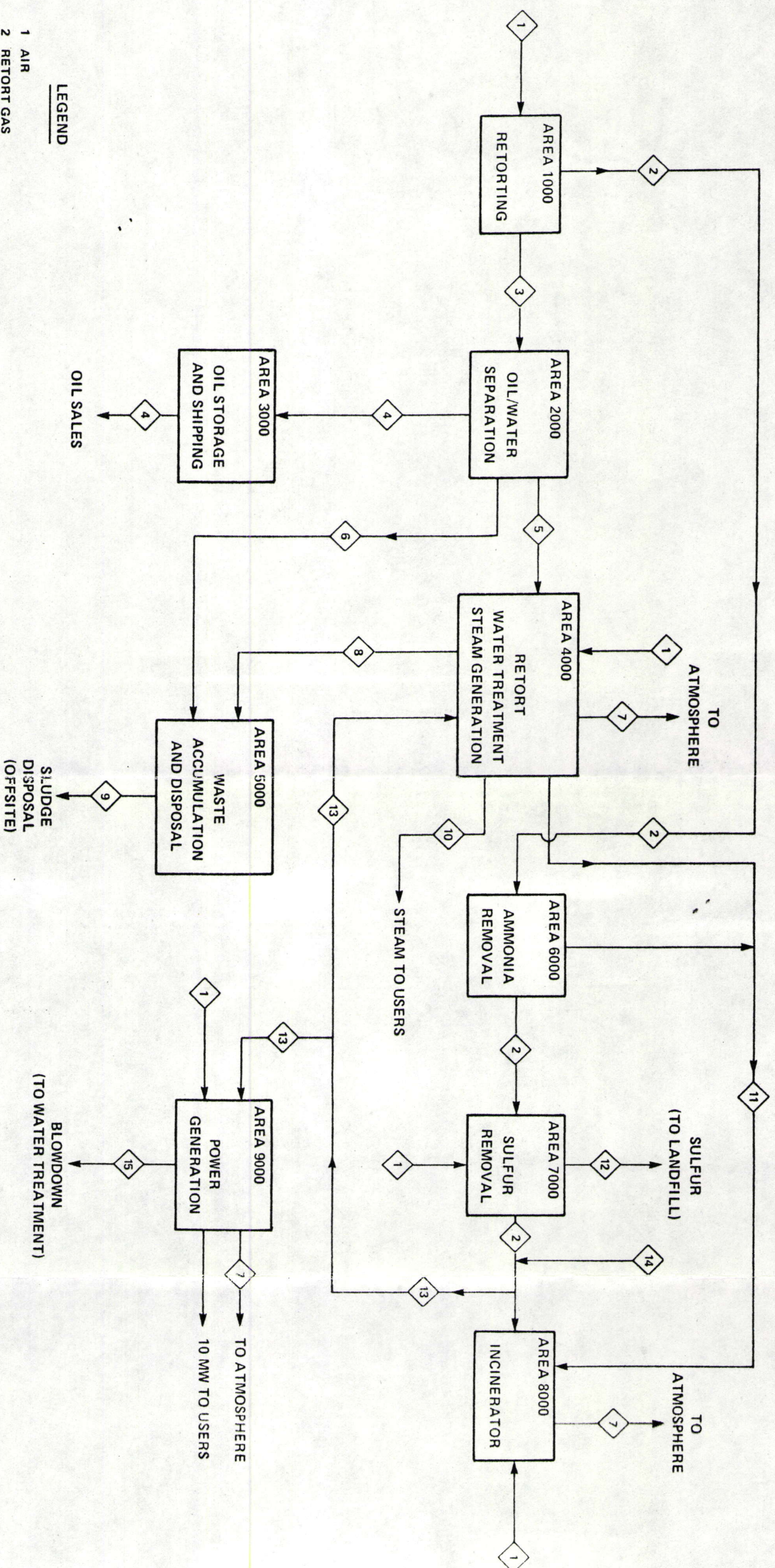
The Geokinetics shale oil production process consists of in-situ retorting and surface processing of produced oil, retort gas, and by-product water. Figure 2-1 is an overall flow diagram showing the major processing steps involved. Figure 2-2 shows the general layout of the surface processing facilities and retort locations.

For ease of discussion, the processes as described by area as identified on Figure 2-1. These areas include:

- o Area 1000 - Retorting
- o Area 2000 - Oil/Water Separation
- o Area 3000 - Oil Storage and Shipping
- o Area 4000 - Retort Water Treatment
- o Area 5000 - Waste Accumulation and Disposal
- o Area 6000 - Ammonia Removal
- o Area 7000 - Sulfur Recovery
- o Area 8000 - Incineration
- o Area 9000 - Power Generation

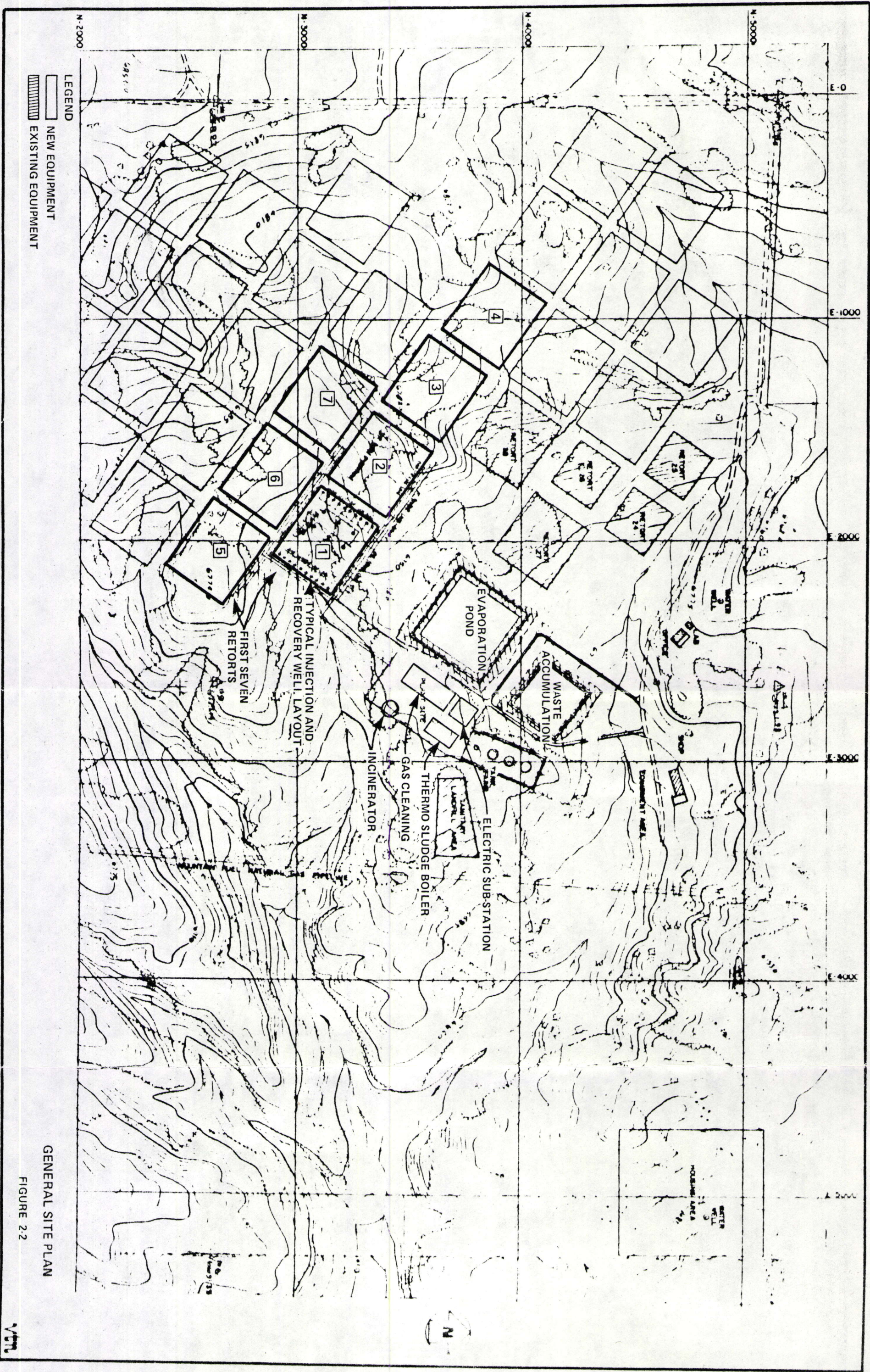
2.1 Area 1000 - Retorting

The retorting area consists of seven in-situ retorts operating simultaneously to produce the design daily volume of 1,000 barrels per day (bpd) of crude shale oil. The seven individual producing retorts are manifolded together such that they deliver their products to a central location but are operated individually. These individual retorts are essentially the same as those that have been operated at the Kamp Kerogen (Seep Ridge) field test site since 1975.



SEEP RIDGE PROJECT
PROCESS BLOCK FLOW DIAGRAM

FIGURE 2-1



The first stage in the development of an in-situ retort is to prepare the land surface above the area to be developed to allow for access by drilling equipment. This is done immediately prior to commencement of drilling operations on a series of retorts so as to minimize the duration of surface disturbance.

Blast holes used for emplacement of explosives into the oil shale zone are drilled using conventional track-mounted rotary air drilling rigs. Ammonium nitrate slurry explosives are used to fracture the shale. The slurry is transported to the retort and loaded down each blast hole using trucks provided by the explosive vendor. The loading truck provides the explosive in the exact quantities and densities prescribed by the blast design. Detonating delays are placed in the hole, and the hole is backfilled to the surface using drill cuttings. On the surface, the holes are tied together so that each hole will detonate at its prescribed delay interval.

At the time of detonation, a series of holes (the initiation round) which comprises approximately one-third of the total, is fired. The blast design is such that the energy created by the detonation of the initiation round lifts the overburden and creates a void beneath it in the oil shale bed. The subsequent holes are fired at their predetermined delay interval, forcing the oil shale laterally into the void created by the initiation round.

As a result of the blast, the surface above the initiation round is permanently uplifted six feet to eight feet, while the remainder of the retort surface remains relatively unchanged. The blast creates a sloped retort floor for oil recovery during operation.

Following the rubblization of the oil shale bed by blasting, wells for air injection, off-gas recovery, oil recovery, and instrumentation access are drilled and cased into the rubble zone. A description of each well type follows.

Air Wells

There are 10 air injection wells placed at one end of each retort. Each is cased with an 8-5/8-inch O.D. steel pipe which is set 10 feet from the retort bottom. The rubble oil shale is ignited from these wells, and air is injected to sustain the combustion processes.

After the drilling and casing process, each of the 10 air injection wells in each retort are connected to a common pipe manifold which receives air from a rotary positive displacement blower. The air from this blower provides the oxygen that sustains combustion during operation of the retorts. Each air injection well is individually valved and metered so that air flows can be varied to control the fire front advance.

Gas Wells

There are 10 off-gas recovery wells on each retort, placed at the terminal end. Each of the 10 off-gas wells in each retort is connected to a common manifold and is cased with 8-5/8 inch O.D. steel pipe to 10 feet above the retort bottom. The gaseous products of combustion and kerogen decomposition are removed from the retort through these wells. Process control is exerted on the fire front by varying the volume and flow distribution of the off-gas recovery. The off-gas is combined and passed through a heat exchanger, a mist knockout tank and a positive displacement vacuum pump. The low pressure gas flows through the main off-gas trunk line to the central processing facility. The liquid collected in the mist knockout tank is combined with the produced oil/water emulsion and sent to the central processing facility through the emulsion trunkline.

Production Wells and Observation Wells

Six production wells and six observation wells are located in pairs on each retort. Three pairs are spaced across the midpoint and three at the terminal end. These wells are drilled to the bottom of the retort and cased with a 6-5/8-inch O.D. steel pipe. The casings in the lower one-third of the retort zone are perforated. These wells are fitted with submersible pumps and used for collection and transfer of the oil/water emulsion condensed within the retort.

All six pumps are operated simultaneously. Oil is recovered from the retort as an oil/water emulsion containing approximately 50% water. The discharge lines from the submersible pumps are manifolded to a degasser tank. Entrained gas from the emulsion passes to the off-gas recovery manifold. The emulsion is pumped to the main emulsion trunk-line for transport to Area 2000 for dewatering.

Instrumentation Wells

Sixty-three uncased instrument wells, each containing four thermocouples (252 thermocouples total), are placed in each retort and connected to an automatic data recorder. The instrument wells are backfilled to the surface with stockpiled drill cuttings. The thermocouples monitor the retort temperature at four vertical levels and are used to aid in process control.

Start-up and Operation

Start-up of an individual retort is a simple procedure. A charge of approximately 50 pounds of charcoal briquettes is placed in each of the 10 air-injection wells. A small charge of briquettes is then ignited on the surface and dropped onto the unlit charcoal down hole. Air injection is commenced and adjusted as necessary to establish a uniform combustion front advance.

The life of an individual retort is 365 days of continuous operation. However, as one retort is depleted, another is ignited. Therefore, the total retort off-gas and oil/water emulsion production is available 365 days per year to the central processing facility.

The total crude shale oil recovered from seven retorts operating simultaneously is 1,000 bpd. The oil/water emulsion produced by these seven retorts also is expected to contain 875 to 1,300 bpd of process water with an average water production of 1,100 bpd.

Individual retorts are shut down when oil production drops to an uneconomical level. The retort is judged to be uneconomic when the crude oil production is insufficient to justify blower power costs and utilization of capital equipment. At that point in time, valves are closed on the air injection and gas production wells which results in extinction of combustion in the retort. Then, the salvageable equipment and piping are removed, and surface reclamation is started.

2.2 Area 2000 - Oil/Water Separation

Crude shale oil is recovered as an oil/water emulsion from the retorts and delivered at an average rate of 2,100 bpd to the central plant site for dewatering, storage and shipment. The emulsion is piped to a 3,000 barrel oil/water separation tank by means of the emulsion trunk line. To decrease the separation process time, a chemical demulsifier is added to the emulsion prior to entering the gravity separation tank. In the tank, the emulsion is heated by internal steam coils to 180°F. The tank volume provides the equivalent of 34 hours of residence time for separation. Oil containing less than 1.0 weight percent water is decanted on a continuous basis from the separation tank and delivered to Area 3000 for storage and shipment.

The separated retort water stream is pumped from the separation tank to the gravity separator. The gravity separator provides secondary oil

recovery by separating and recovering the oil remaining in this water stream. Solids which settle from the water streams are collected in the gravity separator sludge sump and are transferred to Area 5000 for temporary storage and off-site disposal. The oil and accompanying water skimmed from the gravity separator are sent to the oil sump. This stream is recycled to the oil/water separation tank. The effluent water leaving the gravity separator is delivered to Area 4000 for treatment.

The primary oil recovery step that takes place in the oil/water separation tank is expected to operate 360 days per year. During maintenance outages at the oil/water separation tank, the emulsion is stored in one of the crude oil storage tanks for separation later. When retort water treatment is shutdown or at reduced capacity, the retort water is sent to the evaporation pond in Area 5000 for later recovery and use. The gravity separator design is based on processing retort water, plant rainfall runoff and other controlled feeds.

2.3 Area 3000 - Oil Storage/Shipping

Three 10,000 barrel tanks are provided to receive oil from Area 2000. The raw shale oil has a 70°F pour point. Therefore, the tanks are heated with internal steam coils and insulated. Product oil enters the tanks at 180°F and is stored at 150°F so that the oil will be warm when it is shipped. This compensates for the cooling of the oil as it is transported by tanker truck to the refinery. The 30,000 barrel tankage capacity allows a maximum of 30 days storage between shipments.

2.4 Area 4000 - Retort Water Treatment

The purpose of this area is to treat retort water and waste water streams from other plant areas. This is accomplished by the use of the KTI thermosludge water treating process (or an equivalent process) which produces steam and a concentrated slurry of sludge products

from waste feed water. Two KTI thermosludge units are required for normal operation.

The thermosludge water treating and steam generation process internally softens and makes high pressure steam directly from hard and saline oil field water. Pilot plant and full-scale commercial installations have established several physical and chemical principles found necessary for reliable operation and for control and practical elimination of scale on the process heating surfaces. These principles include use of a secondary, liquid heat-transfer medium (residence time for chemical reactions ahead of the boiling zone) and uniform concentration of sludge reaction products throughout the boiling zone.

Retort water from oil/water separation in Area 2000 is combined with blowdown and wastewater from other areas and pumped to the stripper. In the stripper, ammonia is removed overhead and sent to Area 8000.

Stripped water is sent to the boiler feedwater tank and then to the steam generator. Suitable softening reactions in the 350°F to 470°F range take place in the water along its path down the contactor, which is part of the steam drum. The function of the contactor is to provide residence time, high temperature and low carbon dioxide partial pressure to promote bicarbonate decomposition into carbonate and hydroxide, and to promote their recombination with magnesium, calcium and silica. Proper softening requires that these conditions be met: a) enough alkalinity must be available to form solid magnesium hydroxide from all magnesium ions, b) enough carbonate must be available to form solid calcium carbonate from all calcium ions and be in excess depending upon the sulfate ions present, c) enough magnesium must be present relative to the silica content to correspond to the solids formation of at least three magnesium hydroxide to two silica. When conditions a) and b) are fulfilled either naturally or by carbonate addition, the pH rises from a range of 7 to 8 as water enters the contactor, to a pH range of 10 to 12 in the boiling zone.

Feed water containing the necessary chemical additives is pumped to the contactor and allowed to free-fall into the steam drum. The steam drum and the heat exchanger tubes form a thermosyphon circuit. The sludge is continuously withdrawn as blowdown from this circuit. The blowdown stream is flashed off at 10 psig, and the resultant steam is used to heat the feed water in the boiler feed water tank.

Steam from the steam drum contacts the falling feed water in the contactor, preheats it, provides carbon dioxide release, and promotes the chemical reactions described previously. High-purity steam leaves the top of the contactor for delivery to users in other areas of the central plant.

Heat to the outside of the heat exchanger tubes is provided by a circulating stream of commercial heat transfer salt. This salt is pumped from the sump through a furnace to an open distribution pan positioned over the heat exchanger. The salt is a sodium-potassium-nitrate-nitrite eutectic mixture. Since the salt solidifies below 275°F, a natural gas-fired heating tube is provided in the sump for start-up.

The KTI thermosludge boilers are fired with a mixture of the sweet process gas and natural gas.

A total of 31,685 lb/hr of saturated steam at 500 psig is produced by the thermosludge unit. A portion of the steam is used within the area, and 16,146 lb/hr are exported for use in other plant areas. The sludge produced by the KTI boiler is sent to the sludge containment tank in Area 5000 prior to shipment by truck to acceptable waste-disposal sites.

In the event of boiler(s) shutdown, the process water will be diverted to the evaporation pond in Area 5000.

2.5 Area 5000 - Waste Accumulation and Disposal

The waste accumulation area provides surge capacity for retort water and plant runoff streams, and facilities for temporary sludge storage and transfer. The retort water and plant runoff streams are stored and then fed back to the retort water treatment process (Area 4000) at a controlled rate for treatment and reuse of the water as steam. The sludge waste streams generated in the plant are stored temporarily and then removed from the site by tank trucks. The sludge waste is the only stream from the wastewater treatment area not being returned to the process plant for subsequent treatment and reuse.

All plant drains and plant rainfall runoff are directed either to the evaporation pond or small runoff retention ponds to conserve water and to prevent contaminated discharge from the plant. In addition to the above streams, the evaporation pond provides up to 125 days storage capacity for retort water when downstream water treatment operations are not on-line.

2.6 Area 6000 - Ammonia Removal

The purpose of this process area is to remove ammonia (NH_3) from the retort off-gas entering the central processing facility. Ammonia is removed via direct contact between the gas and treated water in a packed tower. Two trains, each capable of handling one-half of the retort off-gas, will be constructed. (Note: These units may not be required if the low- NO_x burner design in the incinerator proves effective in handling the ammonia in the retort off-gas).

Retort off-gas arrives at the central processing plant at approximately 14.0 psia (2.6 psig) and 100°F. The gas enters the bottom of the packed section of the absorber. Treated water enters the top of the packed section of the absorber at 100°F with essentially no NH_3 content. Countercurrent contact between the gas and water absorbs

NH₃ from the gas stream. Clean gas exits the top of the absorber and is sent to Area 7000 for desulfurization and subsequent use as fuel in other processes. Water containing absorbed NH₃ flows from the bottom of the absorber into the stripper feed tank. From the stripper feed tank, the ammonia-laden water is passed through a heat exchanger where the temperature is increased to 200°F. The water then enters the stripper where the ammonia is stripped by steam. The ammonia removed overhead by the stripper is sent to Area 8000 for disassociation to nitrogen and water vapor. The clean water exiting the bottom of the stripper passes through a heat exchanger to preheat the stripper feed. The stripper bottoms are further cooled to 100°F by a fin fan exchanger before entering the absorber to remove more ammonia.

The packed sections of the two ammonia absorbers are designed and operated to achieve an NH₃ level of less than 100 ppm (dry basis) in the exit gas.

2.7 Area 7000 - Sulfur Recovery

The function of this area is to remove hydrogen sulfide (H₂S) from the retort off-gas stream. The primary purpose is desulfurization of the exit gas to a level at which combustion as fuel gas will meet environmental limitations for sulfur dioxide (SO₂) in the flue gas.

The Stretford sulfur recovery process has been selected to meet the design requirements of this project. Stretford is operated commercially for recovery of saleable sulfur from various process gas streams at pressures, temperatures and inlet H₂S concentrations similar to those in this project. The commercial application most analogous to cleaning shale retort off-gas is desulfurization of coke oven gas. Stretford H₂S removal was pilot-tested on shale retort off-gas, including Geokinetics off-gas at Kamp Kerogen during 1982. Theoretically, 99+% H₂S removal can be achieved with proper commercial design and operating control. Two trains, each capable of handling 50% of the retort off-gas, will be constructed.

A modification to the above-mentioned process is presently being evaluated, which employs the ARI Low-Cat catalyst. This catalyst is iron-based, non-toxic, and less sensitive to high pH and could be used as a substitute for Stretford treatment.

Process Description

Gas from the ammonia absorber (Area 6000) enters the Stretford venturi system where it contacts Stretford liquor which absorbs H_2S . Desulfurized gas and Stretford liquor are separated from each other in the gas/ liquor separator. The gas passes through the gas wash drum where any entrained salts are washed out by clean water. The desulfurized gas exits the gas wash drum and is sent to Area 8000.

Stretford liquor is a dilute, aqueous solution of sodium carbonate (Na_2CO_3), sodium metavanadate ($NaVO_3$) and anthroquinone disulfonic acid (ADA). The reactions between the liquor and absorbed H_2S to produce elemental sulfur are complex, and are dependent on liquor temperature and pH which must be controlled during operation. The system operates at essentially isothermal conditions. Overall system water balance is maintained by control of evaporation from the cooling tower.

Nitrogen and excess oxygen in the oxidizer strip dissolved gases from the liquor and float sulfur particles to the surface as a froth which overflows to the froth tank. The froth is filtered to produce a sulfur cake containing 50 to 60 percent water. Excess water containing very dilute Stretford liquor is recycled to the cooling tower basin. The produced sulfur cake is sent to storage.

Emission limitations require that H_2S plus carbonyl sulfide (COS) in the desulfurized fuel gas be 159 ppm or less on a dry basis. This limit requires that 98.5% of the entering H_2S be removed, as Stretford does not remove any of the inlet COS. The Stretford plant will

normally remove 99+% of the entering H_2S . A total of 6.7 TPSD of sulfur cake will be produced at 99+% purity.

2.8 Area 8000 - Low NO_x Incinerator

The purpose of the incinerator is to process various plant effluent streams into an environmentally acceptable discharge stream, allowing disposal of produced wastes (water, gas and ammonia) in the most effective manner.

The thermal incinerator, a 13-foot diameter by 100-foot high refractory-lined vessel, has been designed to process three separate waste streams from the Seep Ridge project. The largest of these streams is the retort off-gas which will be introduced into the bottom of the incinerator where it will be mixed with 90% stoichiometric air and combusted. The remaining 10% stoichiometric along with excess air will be introduced in the upper portion of the incinerator. The second waste stream to be processed is the ammonia stripper overheads from Areas 4000 and 6000. This ammonia-water mixture will be injected into the lower portion of the incinerator where the oxygen deficient atmosphere will inhibit formation of NO_x .

The third stream to be processed will be steam condensate from users. The incinerator has been designed to operate with up to 1,300 bpd of water injected into the upper or oxygen rich section of the incinerator. Besides disposing of the produced water in an environmentally acceptable manner, this water injection reduces temperature in the combustion zone, thus reducing NO_x formation.

The discharge of the thermal incinerator will be a clean gas with less than 150 ppm NO_x and less than 100 ppm SO_x .

2.9 Area 9000 - Power Generation

The process used for the steam power generation facility is a conventional steam/turbine cycle process common to most utility and industrial power plants. Two complete and stand-alone trains of boiler, steam turbine generators, and heat rejection systems are used to generate the nominal power level of 10,000 KW (5,000 KW for each train). The description provided here is for one train only, except where noted.

A mixture of natural gas and retort gas is supplied to the boiler from the gas header just upstream of the incinerator. The combustion air is supplied by two 100% forced draft fans (one spare) to burners designed specifically for low Btu gas. Each boiler is rated at approximately 58,000 lbs/hr of superheated steam at 600 psig and 750°F. The superheated steam is delivered directly to the steam chest of a condensing turbine. A small amount of steam is extracted upstream of the turbine inlet connection for deaeration and feedwater heating. After expansion through the turbine, steam is exhausted at a vacuum condition to a direct dry condenser.

Vacuum pumps are provided to remove the non-condensables from the upper headers of the air condenser and storage tank. They also are used during start-up for establishing the initial vacuum condition.

Steam, after condensation in the direct condenser, is collected in the hot well storage tank where condensate pumps return the condensate to the deaerator for deaeration and feedwater heating. The deaerator is designed to strip oxygen and other noncondensables from the feedwater before entering the boiler. Heated feedwater is pumped via feed pumps from the deaerator directly to the boiler where it is converted to superheated steam, and the entire cycle is repeated.

Make-up water to the plant is provided by water from wells. Well water is pumped and stored in the well water storage tank which supplies water to the water treatment system.

A water treatment system is provided to supply boiler quality water to the turbine cycle to make up for losses in the boiler water and steam. These losses include boiler blowdown (normally 1% to 3% of the rated steam flow) and steam and water losses through the seals of turbines and pumps. The water treatment unit is sized to supply 15 gpm of continuous boiler quality water to handle unexpected losses from the system.

SECTION 3.0

AMBIENT MONITORING PROGRAM

The ambient monitoring program for the Geokinetics project consists of a preconstruction baseline study followed by a Phase I screening program during construction, operation and post-operation of the first set of seven retorts. Phase II (less intensive) monitoring will be conducted during the remainder of the project life (retort sets 2-10). Should parameters other than those indicated by Phase I and baseline monitoring be suggested by agencies or new literature findings, these parameters may be tested during Phase II on a trial basis.

The ambient monitoring program will include surveys of vegetation/soils, wildlife, air quality/meteorology, and hydrology/water quality. A study of these environmental components is considered important in evaluating the potential impacts associated with the Seep Ridge Project.

3.1 Vegetation/Soils

The vegetation and soils monitoring will most likely consist of visual, physical and chemical analyses and will include the parameters prescribed by the Utah Division of Oil, Gas and Mining in the conditions of the Mining and Reclamation permit.

A Mining and Reclamation Plan Permit Application was submitted to the Utah Division of Oil, Gas & Mining in December of 1982. Field investigations are currently under way to collect sufficient information for answering the questions raised in that application. This information will be submitted to the Division in December of 1983. Permit issuance is anticipated in the spring of 1984.

3.1.1 Vegetation

The vegetation study currently underway will provide the following information:

- o Names of organizations that collected and analyzed the data.
- o Dates of collection and analysis.
- o Description of methods.
- o Vegetation maps.
- o Qualitative description of the vegetation types to include discussion on species composition, maturity, past perturbations, correlation with environmental factors and position in the landscape.
- o Information on threatened and endangered species.
- o Effects of operations on vegetation.
- o Mitigation and management plans.
- o Revegetation methods and justifications (coordinated with reclamation plan).
- o Methods and criteria for demonstrating revegetation success.

Phase I ambient monitoring for vegetation will likely consist of:

- o Visual observation/grading of overall site vegetation
- o Visual observation of reference areas.
- o General observations concerning revegetation success of revegetation test plots.
- o Variables indicating plant growth or stress.

The results of the Phase I vegetation monitoring will be compared to the data collected during the preconstruction "baseline" study. Parameters that show patterns or consistency in value in the baseline and Phase I programs will be utilized during Phase II monitoring. Threatened and endangered species surveys have been completed for site flora in June 1983 and will not be conducted in Phases I or II.

The time sequence of Phase I and Phase II vegetation monitoring may be different to that of other ambient and source monitoring programs. The analysis of revegetation success and variables indicating plant growth or stress may take more than one growing season. Hence, Phase I for revegetation may continue into retort sets two and three prior to establishing Phase II monitoring.

3.1.2 Soils

Order 2 level surveys will be performed during the "baseline" studies to provide adequate data for the design of soil handling and conservation measures during operation and for reclamation planning. All procedures for the topsoil resource assessment, including field methods for soil mapping and sampling, laboratory sample analysis, subsequent data analysis and topsoil stripping depth recommendations, report development and all necessary volumetric calculations will be in accordance with the current Utah Division of Oil, Gas & Mining regulations.

Phase I and Phase II soils monitoring will be conducted during construction, operation and post-operation as may be specified in the mining and reclamation permit.

3.2 Wildlife

In addition to preconstruction wildlife monitoring, Phase I monitoring will be conducted during construction, operation and post-operation stages. The major objective of the wildlife monitoring program will be to determine if the shale processing activities (including construction and reclamation) affect the abundance and distribution of wildlife species near the site. Thus, any departure from normal conditions or significant changes in the wildlife populations will be measured and evaluated. In the preconstruction and Phase I monitoring efforts, big game abundance, threatened and endangered species, raptor nesting and

activity, and other investigations associated with wildlife use of the area will be conducted. (These studies are part of on-going environmental investigations presently being conducted.)

Phase II monitoring will emphasize the use of indicator parameters that are derived in Phase I and the preconstruction program. It is expected that raptor surveys and investigations into the usage of the area by rare, threatened or endangered species will continue to be conducted during Phase II monitoring.

3.3 Air Quality and Meteorology Monitoring

The air quality/meteorology monitoring program will document existing conditions around the Geokinetics site and will assist in defining the existence of any environmental impacts resulting from the project.

3.3.1 Meteorology

The on-going, meteorology monitoring program consists of a 30-meter meteorological tower situated near the center portion of Section 2. Instrumented at the 10- and 30-meter levels, the parameters measured are wind speed, wind direction and temperature. Additionally, atmospheric stability is calculated by the data acquisition unit via the sigma-theta method. The wind speed and direction sensors are Weathermeasure, the temperature sensors are YSI and the data acquisition unit is from Handar. This system has been in operation since January 1983. All sensors meet PSD monitoring specifications and have been reviewed by the Utah Bureau of Air Quality. The meteorology monitoring plan has also been approved.

3.3.2 Air Quality

Baseline air quality for the Geokinetics site has been documented by the air quality studies conducted by the White River Shale Project.

The State of Utah has ruled that data submitted by WRSP is acceptable as describing the air quality in and around the Seep Ridge Site. (Although UBAQ has agreed to allow Geokinetics to use the WRSP air quality data for the baseline, a comparative study to show the representativeness of the data may be conducted.) Operational phase ambient air quality monitoring requirements for either air quality or meteorological parameters will be set by the conditions accompanying the Prevention of Significant Deterioration Permit. There are no a priori monitoring requirements specified by the State of Utah (Utah Air Conservation Regulations, Section 3.6.5 b[1][b]). Based on conversations with the Utah Bureau of Air Quality, it appears that SO₂ and possibly NO_x monitoring may be needed. If monitoring is included as a PSD permit condition, the probable location(s) will be at the point of maximum off-site concentration(s), as predicted by the modeling results accompanying the approved PSD permit. The data must be gathered using EPA Reference Methods (or an equivalent) and quality assurance equivalent to 40 CFR 58. In any event, monitoring will be as defined by requirements for obtaining a PSD permit from the Utah Bureau of Air Quality.

3.4 Hydrology/Water Quality

Hydrology and water quality monitoring for the Seep Ridge project will be designed to monitor ground and surface water resources. The program will identify potential impacts/effects of oil shale processing operations on existing hydrology and water quality. In addition, it will compare the concentration of selected parameters with existing standards and baseline data; such parameters are to be selected on the basis of the baseline data collection program and Phase I, as well as those defined in the Source Monitoring Program (Section 4.2).

3.4.1 Surface Water

Surface water is extremely limited on site. No natural ponds or well-defined channels exist on the Seep Ridge site. As a result,

surface water monitoring will be limited to periodic sampling of runoff retention ponds. Such determinations, while conducted infrequently (for example, once per year) will assist in determining water quality should an upset condition occur. Water quality parameters which may be used on the monitoring program are shown in Table 3-1.

3.4.2 Ground Water

Ground water occurs in measurable quantities perched in near-surface zones within the overburden above the retorts. This water will be locally affected by oil shale operations. Geokinetics recognizes this potential concern and will address ground water monitoring in the following manner.

Preconstruction and Baseline Monitoring

Sampling wells are presently being planned to document baseline ground water flow conditions and aquifer characteristics. Parameters to be measured will be those described in the Source Monitoring Program.

Existing data on pre- and during-burn conditions within retorts have indicated that some changes in water quality occur as the retorting proceeds. These data will be used as a basis for further monitoring activities to be performed under the Source Monitoring Program (see Section 4.0).

Phase I Monitoring

Following the baseline investigations, Geokinetics will develop a Phase I program that is designed to gain further information on the ground water conditions surrounding Sections 2 and 32. Current plans call for a series of wells drilled into relatively impermeable strata to a depth equal to approximately 50 feet below the lowest elevation of the base

TABLE 3-1
WATER QUALITY PARAMETERS

Major Cations

Calcium
Magnesium
Sodium
Potassium
Lithium
Strontium

Major Anions

Chloride
Carbonate-Bicarbonate
Sulfate

Trace Metals

Boron
Iron
Silica
Antimony
Lead

Other Quality Indicators

pH
Conductivity
Total Dissolved Solids
Chemical Oxygen Demand
Alkalinity
Total Suspended Solids*

Other Indicators

Thiosulfates
Thiocyanates
Ammonia
Ammonium
Alkyl Pyridines
Cyanide
Sulfides
Total Sulfur
Carbonyl Sulfide
Fluoride

Organics

Oil and Grease
Total Organic Carbon
Total Organic Nitrogen
Phenols

*Surface water samples only.

of the planned retorts. These wells will supply additional ground water data on area water quality.

Phase I data will be compared to the baseline data collected earlier to determine any impacts on water quality. Indicator parameters that are useful in defining the ground water regime and that are cost-effective to monitor will be derived for Phase II monitoring.

Phase II Monitoring

Phase II monitoring during the construction and operation of the second set of retorts and thereafter will consist of periodic analyses of "routine" parameters, that is, parameters that have been shown to be useful to define the existing water quality and which are cost-effective. Samples will be collected from the series of monitoring wells used during the Phase I program. Should these wells not be available, new wells will be drilled to a comparable depth in a nearby area so that the data obtained are comparable.

3.5 Antiquities

An archaeological survey on Section 2 was conducted in 1979. An additional survey, investigating antiquities resources on Section 32, will be conducted this summer. The report should be available by December 1983. No other antiquities studies are planned.

3.6 Socioeconomics

A socioeconomic study to evaluate the impacts, if any, of the project on the Ute Indian Tribe has been initiated by the tribe and financed by Geokinetics and the Tribe. The findings will be presented in a report by the end of 1984.

A small scale study discussing the impacts of the additional work force (about 50 employees) on the nearby communities is presently underway.

SECTION 4.0

SOURCE MONITORING

This chapter presents an overall approach to the characterization of regulated and unregulated pollutants of potential environmental and health concern. The source monitoring program is divided into two major sections: a compliance monitoring program that will address regulated pollutants associated with permit/approval conditions, and a supplemental monitoring program that will address both regulated and unregulated pollutants not included in the compliance monitoring program.

4.1 Compliance Monitoring

Regulated pollutants to be monitored as part of the compliance monitoring program include gaseous emissions and solid waste effluents. The facility has been designed to achieve zero discharge of wastewaters. Therefore no related compliance monitoring requirements are anticipated. Potential surface water and ground water resource impacts are addressed in the ambient monitoring plan (see Section 3.0).

4.1.1 Gaseous Emissions

Gaseous emissions monitoring will be set by the conditions accompanying the Prevention of Significant Deterioration permit when it is issued by the Utah Bureau of Air Quality. According to Utah Air Conservation Regulations, Section 4.6, no continuous emissions monitoring will be required. Such monitoring is needed only for: 1) fossil fuel fired steam generators with a heat input greater than 250 MM BTU/hour, 2) nitric acid plants, 3) sulfur burning production acid plants, and 4) fluid bed catalytic cracking unit catalyst regenerators. Compliance testing is expected to be required for the boilers and incinerator.

The other monitoring requirements primarily address leaks from project components that handle volatile organic compounds (VOC). The pollutant, methods and frequency are given in Table 4-1.

4.1.2 Solid Wastes

Solid wastes generated in the process will include oily sludge from oil/retort water separation (Area 2000), KTI boiler sludge (Area 4000), and other miscellaneous minor sludge waste streams, such as boiler blowdown. Each solid waste stream will be analyzed according to the criteria set forth under the Resource Conservation and Recovery Act. These criteria include corrosivity, reactivity, ignitability and EP toxicity. Non-hazardous wastes will undergo supplemental monitoring as discussed in Section 4.2. Hazardous wastes will be transported off-site for disposal in an approved hazardous waste disposal site and will not require further monitoring by Geokinetics.

4.2 Supplemental Monitoring

The U.S. Synthetic Fuels Corporation (SFC), in its Environmental Monitoring Plan Guidelines (July 28, 1983) requires the monitoring of unregulated pollutants in air emissions, water effluents, and solid wastes from synthetic fuels plants requesting federal assistance. Unregulated substances are defined as those which are "not presently regulated under any law and those which may be regulated under one law but not another" which may be present at concentrations of "significant environmental or health concern." Such monitoring will be directed at producing "environmental and health data, not otherwise required by compliance monitoring, which are relevant to project replication."

The purpose of this section is to outline a supplemental monitoring program for the Geokinetics process that is in compliance with the Guidelines. The proposed program uses a two-phase approach to monitor unregulated pollutants in air emissions, water effluents and solid

TABLE 4-1

ANTICIPATED COMPLIANCE MONITORING REQUIREMENTS
FOR GASEOUS EMISSIONS

Pollutant	Project Component	Frequency	Method
Particulates, SO ₂ , NO _x , CO	Incinerator, boilers	Once within 180 days of start-up	Particulates: EPA Methods 1-5 & 9 SO ₂ : EPA Methods 1-4 & 6 NO _x : EPA Methods 1-4 & 7 CO: EPA Method 3
Volatile Organic Compounds (VOC)	All pump seals, pipeline valves in liquid service, storage tanks (if RVP exceeds 78 mm Hg)	Annually	Portable VOC detection device
VOC	All compressor seals, pipeline valves in gaseous service, vapor lines and couplings	Quarterly	Portable VOC detection device
VOC	All pump seals	Weekly	Visual inspection for leaks
VOC	All vapor lines and couplings	Monthly	Visual inspection for leaks
VOC	Any component in which a leak has been detected	Immediately after repair	Appropriate device
VOC	All components in which a leak has been detected	Annually	Leak report
Particulates, NO _x , CO, VOC, SO ₂	All emissions sources	Annually	Emissions Inventory
H ₂ S	Stretford Tail Gas	Not specified (to be deter- mined)	Not specified (to be determined)

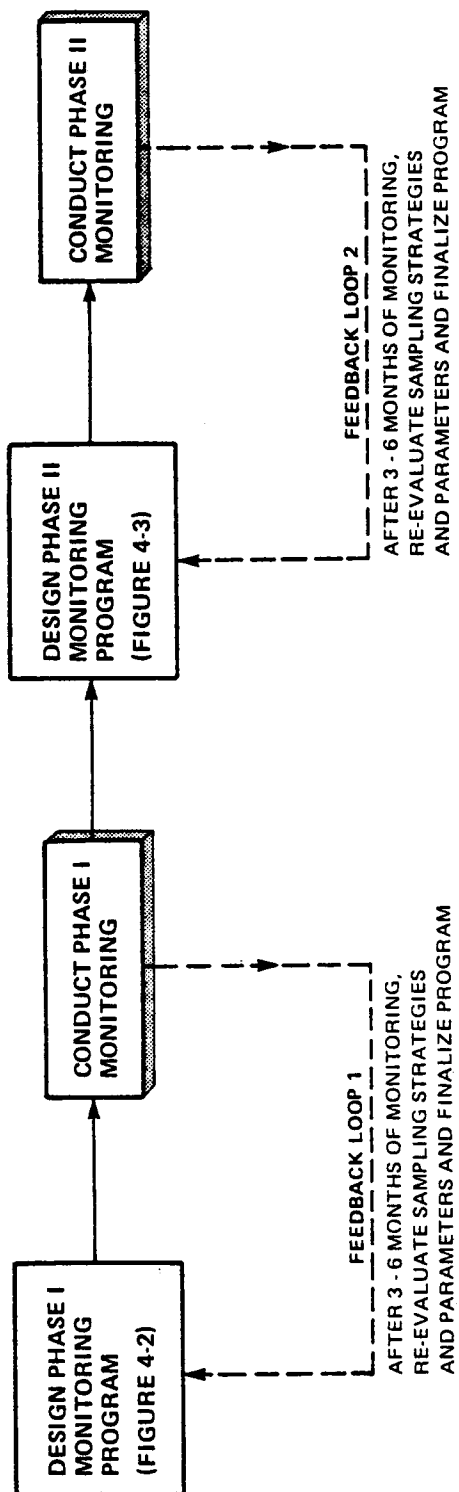
wastes during the operational life of the facility (Figure 4-1). The first phase emphasizes a number of screening techniques to identify substances of environmental and health concern. The second phase evaluates the resulting data using Minimum Acute Toxicity Effluent (MATE) values to develop a streamlined and cost-effective program that is responsive to environmental and health concerns.

4.2.1 Phase I Monitoring

The purpose of the Phase I program is to establish an emissions baseline and to assess the performance of pollution control systems. Unregulated pollutants will be monitored in air emissions, water effluents, and solid wastes as they are released from the plants' vents, stacks, pipes, conveyors, etc. Unregulated pollutants will also be monitored before and after important pollution control devices during start-up, shutdown and upset conditions in the operational phase. (Source monitoring will not be performed during preconstruction and post-operation of the facility; however, ambient monitoring will continue throughout these periods.) Phase I monitoring will include both survey and routine analytical programs to completely characterize the wastes.

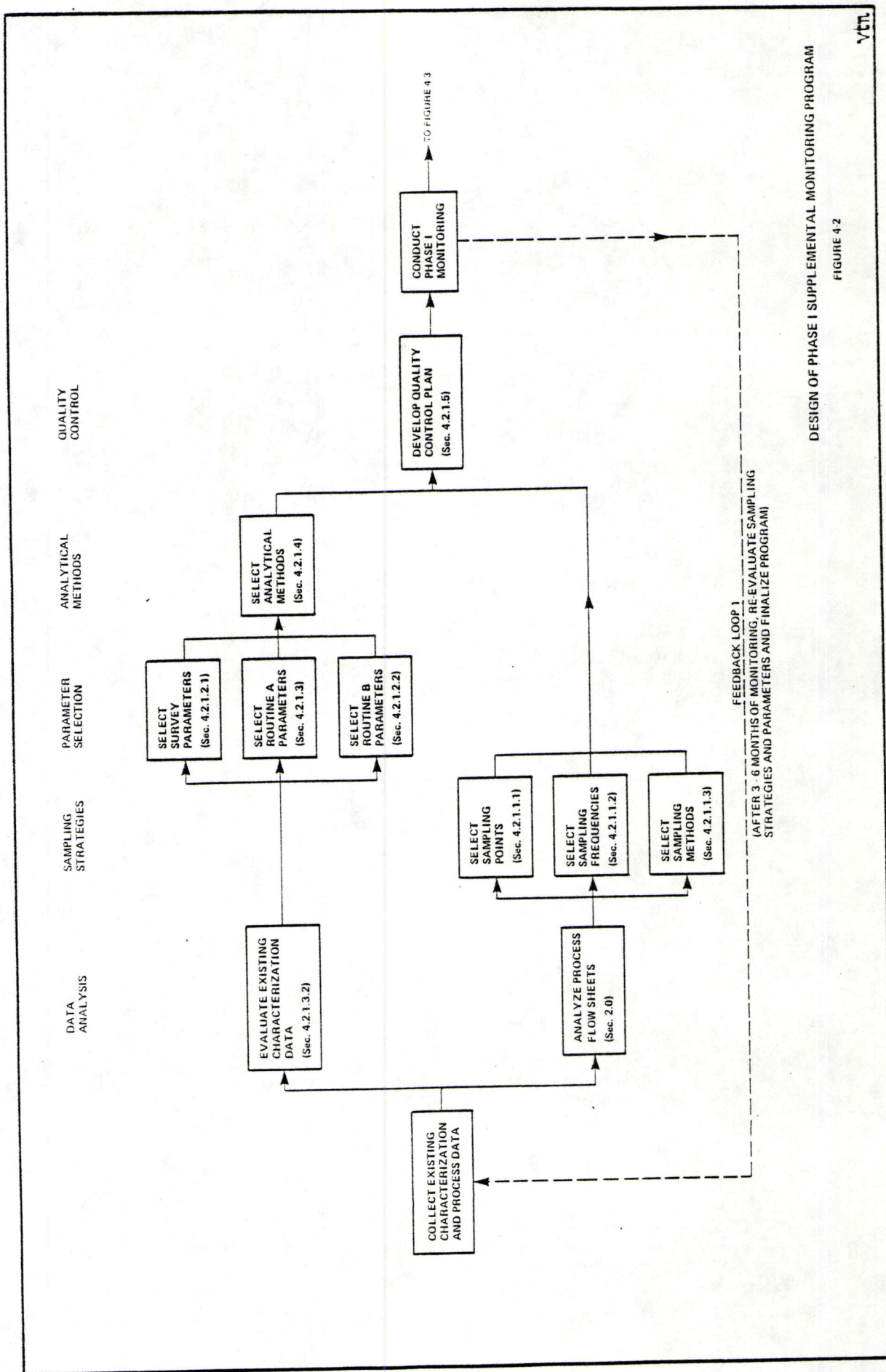
The procedure that was used to develop the Phase I Supplemental Program is briefly described here (refer to Figure 4-2).

The elements of a monitoring program are sampling strategies (see 4.2.1.1) (points, frequency, methods); the parameter list; analytical methods; and a quality control program. The details of each of these monitoring program elements were determined by evaluating existing characterization and process data.



SUMMARY OF SUPPLEMENTAL SOURCE MONITORING PROGRAM

FIGURE 4-1



DESIGN OF PHASE I SUPPLEMENTAL MONITORING PROGRAM

FIGURE 4.2

Sampling points were selected from detailed process flow diagrams for each plant area. These diagrams were studied to identify points where wastes may be released to the environment. (Each plant area is described in Section 2.0.) The resulting list of sampling points is discussed in Section 4.2.1.1.1 and summarized on Table 4-2. Sampling frequency was determined from information on probability of release, waste source, and waste variability. This was achieved by analyzing available process and characterization data. Important considerations in setting sampling frequencies are discussed in Section 4.2.1.1.2. Methods to sample each waste were determined from knowledge of physical and chemical conditions at each site and from general information on sampling and oil shale chemistry. Sampling methods are reviewed in Section 4.2.1.1.3. The resulting frequencies for normal and upset conditions are summarized in Table 4-3.

Important unregulated parameters were identified by evaluating existing chemical characterization data on the Geokinetics process. Three different classes of parameters were selected to accommodate the relative amount of available information and to address two distinct monitoring goals, as follows:

- o Environmental Monitoring - Wastes that are discharged or exposed to the environment (as in an evaporation pond) will be characterized to identify substances of significant environmental or health concern.
- o Pollution Control Monitoring - Liquid and gaseous waste upstream and downstream from important pollution control devices will be monitored to evaluate system performance.

The three classes of parameters correspond to three monitoring strategies, as follows:

Table 4-2. Sampling points for Phase I supplemental source monitoring.

SAMPLING POINT	PLANT AREA
SOLIDS	
<u>Discharged</u>	
Retort Area Fugitive Dust	1000
<u>Exposed</u>	
Byproduct Sulfur	7000
In Situ Spent Shale	1000
In Situ Raw Shale	1000
<u>Contained</u>	
Sludge	5000
LIQUIDS	
<u>Discharged (a)</u>	
In Situ Retort Leachates	1000
<u>Exposed</u>	
Evaporation Pond	5000
<u>Contained</u>	
Stripper Feed	4000
Stripper Overheads	4000
Stripper Bottoms	4000
KTI Boiler Feedwater	4000
Steam from KTI Boiler	4000
GASES	
<u>Discharged</u>	
KTI Boiler Flue Gas	4000
Incinerator Flue Gas	8000
Power Generation Flue Gas	9000
Oil/Water Separation	
Fugitive Emissions	2000
Oil Storage/Shipping	
Fugitive Emissions	3000
Retort Area Fugitive Emissions	1000
<u>Contained</u>	
Retort Gas	1000
Absorber Offgas	6000
Sulfur Removal Washed Gas	7000

(a) Retort leachates are not "discharged" in the usual sense, e.g., from a pipe. Rather, they are in-situ effluents which may be transported beyond the plant boundary due to natural hydrologic factors. (See Sec. 4.2.1.1.1 for a definition of "discharged" in the sense used here.)

Table 4-3. Recommended sampling frequencies for the supplemental monitoring program.

WASTE	SURVEY	ROUTINE A	ROUTINE B
<u>UPSET CONDITIONS</u>			
PROCESS WASTES			
CONTAINED	One grab sample during any emergency which involves leakage from containment. Sample only at site of emergency.	One grab sample during any emergency which involves leakage from containment. Sample only at site of emergency.	No sampling.
EXPOSED	One composite sample during each emergency condition.	One composite sample during each emergency condition.	Not applicable.
DISCHARGED	One composite sample for each emergency condition of 2 days or less and two for emergencies longer than 2 days.	Daily composite samples for duration of condition up to, but not to exceed, 5 days.	No sampling.
NONPROCESS WASTES			
CONTAINED	No sampling.	No sampling.	No sampling.
EXPOSED	One grab sample during each emergency condition.	No sampling.	No sampling.
DISCHARGED	One grab sample during each emergency condition.	No sampling.	No sampling.
<u>NORMAL CONDITIONS</u>			
PROCESS WASTES			
CONTAINED	No sampling.	One composite sample during each of two 5-day sampling periods.	Daily composite samples during one 5-day sampling period.
EXPOSED	One composite sample during each of two 5-day sampling periods.	One composite sample during each of two 5-day sampling periods and quarterly at all other times.	Not applicable.
DISCHARGED	Two composite samples during each of two 5-day sampling periods and quarterly at all other times. Organics will be measured in every other sample.	Daily composite samples during each of two 5-day sampling periods and quarterly at all other times.	Daily composite samples during one 5-day sampling period.
NONPROCESS WASTES			
CONTAINED	No sampling.	No sampling.	No sampling.
EXPOSED	One composite sample during each of two 5-day sampling periods.	No sampling.	No sampling.
DISCHARGED	One composite sample during each of two 5-day sampling periods.	No sampling.	No sampling.

- o Survey Monitoring - No characterization data exists on some of the waste streams that will be generated by the proposed 1,000-bpd facility. Analytical methods capable of simultaneously detecting many constituents are used to screen these wastes. The resulting data will be compared with criteria, and environmentally important parameters are incorporated into the Routine A program.
- o Routine A Monitoring - Existing characterization data is used to identify those constituents which are of significant environmental or health concern. This is done by comparing waste concentrations with accepted criteria. These parameters are monitored in all applicable plant wastes to develop an environmental baseline.
- o Routine B Monitoring - Performance parameters, such as organic carbon and NO_x , are measured upstream and downstream from important pollution control devices. The resulting data is used to determine whether conventional pollution control devices function as designed on the unique wastes produced by shale plants. Routine A monitoring also is performed at selected locations to determine the ability of pollution control devices to remove environmentally important, unregulated parameters.

4.2.1.1 Sampling Strategies

The proposed program will span a minimum of one year of plant operation and will include monitoring during normal operation and start-up, shutdown and upset conditons. The program will include two five-day intensive sampling trips to determine the composition of steady-state waste streams. All waste streams will be sampled at specified periodic intervals throughout the one-year period and during upset conditions. Performance of pollution control devices also will be assessed.

Some of the same sampling points selected for regulated pollutants also will be used for unregulated pollutants. However, new sites will be included to evaluate pollution control system performance and to characterize unregulated wastes. Separate samples may have to be taken for unregulated pollutants due to special sample handling, preservation requirements, and large volume requirements. Eight-hour composite samples will be taken for most wastes to minimize variability due to plant operation, to approximate the exposure received by on-site workers (for use in the health monitoring program), and to provide large-volume weighted (flow or mass) samples.

4.2.1.1.1 Sampling Points

The sampling points that will be used for supplemental source monitoring are summarized in Table 4-2. These were selected by identifying points on process flow diagrams where wastes may be released into the environment. The plant area and stream number, noted in Table 4-1, correspond to those used on the process flow diagrams in Section 2.0. Additional information on each waste stream is included in Section 2.0. The type of monitoring (environmental, pollution control) and sampling frequency at each site depend on the likelihood that a waste will interact with the environment. Therefore, the sampling points have been categorized as follows:

- o Contained - Contained wastes are those which are completely contained within a recycle pipe or tank and which have no interaction with the environment.
- o Exposed - Exposed wastes are those which are stationary and in direct contact with the environment. Exposed wastes include those contained in ponds, open tanks, landfills and underground retorts.

- o Discharged - Discharged wastes are those which are released from the plants' vents, stacks and pipes into the environment and which are transported beyond the confines of the plant.

4.2.1.1.2 Sampling Frequency

The sampling frequency for each waste is determined by evaluating the probability of release or worker exposure; plant operational phase (normal, upset); source of waste (process, nonprocess); type of analyses (survey, routine) and waste variability. The sampling frequencies recommended for the supplemental program are summarized in Table 4-3.

The principal factor in setting monitoring frequency is the likelihood that the waste will interact with the environment. Similarly, the probability that the waste will come into contact with on-site workers, the general population, or the local environment will depend on whether such a waste is contained (as in a recycle pipe), exposed to the environment (as in a pond, open tank, or landfill), or discharged and transported beyond the plant boundary.

The source of the waste within the plant is also important in setting sampling frequencies. Wastes which are unique to oil shale plants (process wastes) require more extensive monitoring than conventional wastes (nonprocess wastes) which are common in many other types of industrial installations. Accordingly, in the Phase I program, process wastes are monitored more frequently than nonprocess wastes.

Plant operational phase also determines sampling frequency. Because of the transient nature of upsets, start-up and shutdown, less frequent monitoring will occur during upset conditions than during normal operation.

Finally, the type of analyses must be considered in setting sampling frequencies. Survey monitoring will use analytical methods capable of multi-element or multi-compound analyses. Some of the constituents will be accurately measured, while others will not due to matrix and other interferences. Routine monitoring on the other hand uses more accurate analytical methods to measure substances which, initially, will have a high probability of being incorporated into the Phase II program. Thus, survey monitoring will be performed much less frequently than routine monitoring.

4.2.1.1.3 Sampling Methods

Liquids and solids will be sampled using conventional methods. Proportional sampling devices will be used to collect eight-hour composite samples of high-volume process wastes. Gases will be collected in impinger trains or on adsorbents for trace element analyses and adsorbed onto resins for trace organics analyses. Both adsorbents (precleaned coconut charcoal) and impinger trains will be used on at least 10% of the samples from the survey program for gaseous trace element analyses. This is necessary because neither collection method will trap efficiently all of the elements that are suspected to be present (e.g., As, Br, Cl, Cr, Mo, Se, Sb, Hg, F). Particulates will be collected from gas streams onto an appropriate filter paper (e.g., quartz fiber) contained in stainless steel holders or by cascade impactors and handled and analyzed as for other solids.

4.2.1.2 Parameter Selection for Survey and Routine B Monitoring

Parameters will be selected for Phase I supplemental monitoring using two separate procedures which address relative knowledge of Geokinetics wastes. Extensive waste characterization and on-site sampling have been conducted in conjunction with earlier, experimental retorts at the Seep Ridge site. The majority of this work focused on retort water, retort gas, raw shale, and spent shale. These data represent an

existing baseline emissions inventory which will be used to select unregulated parameters for "Routine A" supplemental monitoring. The selection of Routine A parameters will be discussed in Section 4.2.1.3.

Other waste streams (e.g., sludge) are unique to the proposed 1,000 bpd commercial facility and have not been characterized previously. "Survey" supplemental monitoring will be used for these uncharacterized wastes. Still other waste streams do not require supplemental monitoring but must be monitored to evaluate pollution control performance. "Routine B" monitoring will be performed on these. The types of monitoring (Routine A and B) recommended to evaluate environmental impacts and performance of pollution control devices is summarized in Table 4-4 for each sampling point.

The next two subsections (4.2.1.2.1 and 4.2.1.2.2) overview the approach that was used to select parameters for survey and Routine B monitoring. Section 4.2.1.3 presents similar information for Routine A parameters.

4.2.1.2.1 Survey Monitoring

These analyses will be performed only on those wastes which have not been previously characterized. The purpose of these analyses is to determine the chemical composition of wastes in those cases where there are inadequate data and to select Phase I Routine A parameters. Survey analytical methods will be used to determine the organic and inorganic compounds present in some process and nonprocess wastes. Biological testing also will be used to indicate the presence of compounds which are mutagenic, but which may not be detected by survey analyses or identified as such in subsequent reviews of the data. The wastes to be measured and parameters recommended for survey monitoring are summarized in Tables 4-4 and 4-5.

Table 4-4. Phase I supplemental source monitoring requirements.

SAMPLING POINT	ENVIRONMENTAL		POLLUTION CONTROL SYSTEMS	
	SURVEY	/ROUTINE A	ROUTINE A/ROUTINE B	
SOLIDS				
<u>Discharged</u>				
Retort Area Fugitive Dust	X (a)			
<u>Exposed</u>				
Byproduct Sulfur	X			
In Situ Spent Shale (b)	X (ORG) (c)			
In Situ Raw Shale (b)	X (ORG)			
<u>Contained</u>				
Sludge	X			
LIQUIDS				
<u>Discharged (d)</u>				
In Situ Retort Leachates	X (ORG)	X		
<u>Exposed</u>				
Evaporation Pond	X (ORG)	X		
<u>Contained</u>				
Stripper Feed			X (e)	X
Stripper Overheads			X (e)	X
Stripper Bottoms			X (e)	X
KTI Boiler Feedwater			X (e)	X
Steam from KTI Boiler	X		X (e)	X
GASES				
<u>Discharged</u>				
KTI Boiler Flue Gas	X	X		X
Incinerator Flue Gas	X	X		X
Power Generation Flue Gas	X			
Oil/Water Separation				
Fugitive Emissions	X (ORG)			
Oil Storage/Shipping				
Fugitive Emissions	X (ORG)			
Retort Area Fugitive Emissions	X	X		

Table 4-4. (Continued)

SAMPLING POINT	ENVIRONMENTAL		POLLUTION CONTROL SYSTEMS	
	SURVEY	/ROUTINE A	ROUTINE A/ROUTINE B	
GASES				
<u>Contained</u>				
Retort Gas			X (e)	X
Absorber Offgas			X (e)	X
Sulfur Removal Washed Gas			X (e)	X

(a) An "X" indicates that monitoring is required. The specific parameters that are to be measured are summarized in Table 4-5 (Survey), Table 4-6 (Routine B), and Table 4-7 (Routine A). The sampling frequencies to be used are summarized in Table 4-3.

(b) A single sample of raw and spent shale will be characterized. Existing cores from earlier retorts will be composited over their length and the composite will be characterized for organics. The elements B, F, Ag, Hg, Cd, and Te also will be quantitated in the same composites. (See note (b) on Table 4-7.) Routine A and inorganic survey analyses are not required for raw and spent shales. (See discussion in Sec. 4.2.1.3.2, "Solids".)

(c) The notation (ORG) signifies that only organic analyses, as specified in Table 4-5, will be performed. Inorganic survey analyses are not required due to the extensive existing data on these wastes.

(d) Retort leachates are not "discharged" in the usual sense, e.g., from a pipe. Rather, they are in-situ effluents which may be transported beyond the plant boundary due to natural hydrologic factors. (See Sec. 4.2.1.1.1 for a definition of "discharged" in the sense used here.)

(e) A single sample will be characterized for Routine A parameters (Table 4-7) to assess the ability of pollution control devices to remove unregulated pollutants.

Table 4-5. Parameters recommended for Phase I survey monitoring in the supplemental program.

PARAMETERS (a)

INORGANICS (b)

Ag, Al, As, Au, B, Ba, Be, Bi, Br, Ca, Cd, Ce, Co, Cr, Cs, Cu, Dy, Er, Eu, F, Fe, Ga, Ge, Gd, Hf, Hg, Ho, I, In, Ir, K, La, Li, Lu, Mg, Mn, Mo, Na, Nb, Nd, Ni, Os, P, Pa, Pb, Pt, Pr, Rb, Re, Rh, Ru, S, Sb, Sc, Se, Si, Sm, Sn, Sr, Ta, Tb, Te, Th, Ti, Tl, Tm, U, V, W, Y, Yb, Zn, Zr

ORGANICS (c)

major volatile and semivolatile organic compounds in each of the following classes: benzenes, indans, indenenes, naphthalenes, benzoic acids, aldehydes, ketones, phenols, furans, nitriles, amines, pyrroles, pyridines, quinilines, and thiophenes

priority pollutants (d)

BIOLOGICAL ACTIVITY

mutagenicity

(a) These parameters will be measured in the wastes marked by an "X" in the survey column of Table 4-4. The recommended sampling frequencies are summarized in Table 4-3 under the survey column. The analytical methods that will be used to measure each parameter are summarized in Table 4-12.

(b) Many of these elements (e.g., Er, Os, Pa, Pr) have not been detected and are not suspected to be present in oil shale wastes. All of these elements are simultaneously measured by spark source mass spectrometry, the analytical method selected for survey monitoring. (See Section 4.2.1.4.1 and Table 4-12).

(c) The specific organic compounds that will be monitored will be those that may be reasonably expected to be present in oil shale wastes. These will be determined by inspecting published and unpublished organic analyses of Geokinetics and other oil shale wastes and selecting indicator compounds for each class. The indicator will be an environmentally important compound present at an elevated concentration. Selected compounds may include priority pollutants.

(d) Pesticides and halogenated aliphatics will not be monitored.

4.2.1.2.2 Routine B Monitoring

Regulated and unregulated parameters necessary to evaluate the performance of liquid and gaseous pollution control devices will be monitored. The specific parameters depend upon the control technology (described in Section 2.0). The recommended parameters for the Geokinetics process are presented in Table 4-6. In addition, one set of samples taken during normal plant operation will be monitored under the Routine A program (see 4.2.1.3.2) to assess the ability of pollution control devices to remove unregulated pollutants.

4.2.1.3 Parameter Selection for Routine A Monitoring

This section first describe the methodology (Section 4.2.1.3.1) that will be used to select Routine A parameters. This methodology then is applied to Geokinetics waste (Section 4.2.1.3.2). The wastes first are characterized. They then are compared with criteria, and parameters which exceed criteria are selected for Routine A monitoring. This procedure is more complex than that used to select survey and Routine B parameters, and the reader may wish to refer to Figure 4-3 for orientation.

4.2.1.3.1 Methodology

Routine A analyses will be performed only on those parameters present in Geokinetics wastes which have been previously characterized. Parameters present in wastes at concentrations that exceed environmental and health criteria will be monitored. Routine analyses will be performed more frequently than survey analyses, and more accurate and precise analytical methods will be used.

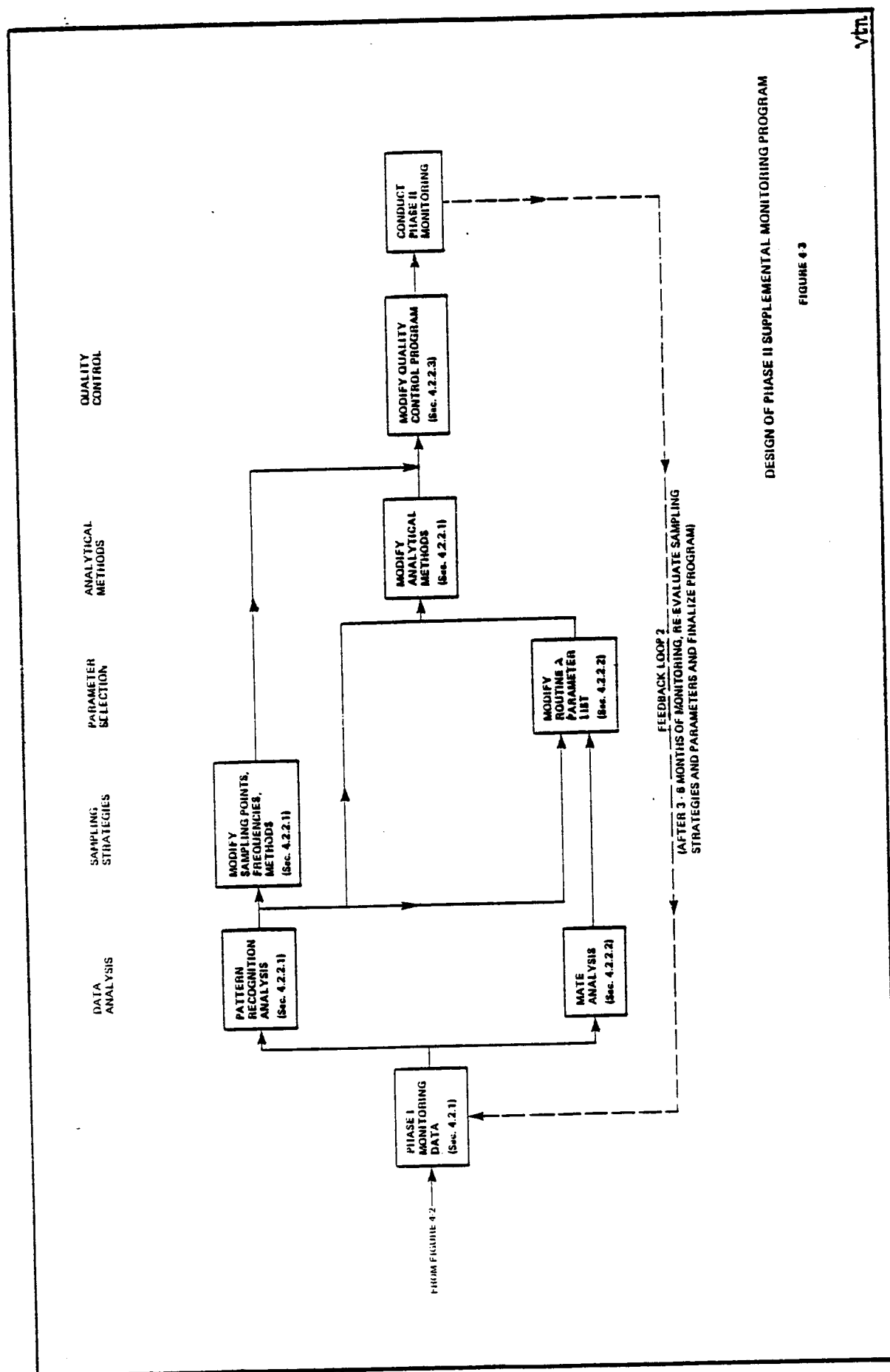
Parameters important for environmental and health reasons will be selected by comparing reported concentrations in various solids, liquids, and gases from the Geokinetics process with Minimum Acute Toxicity Effluent (MATE) values as reported by the EPA (Cleland and

Table 4-6. Parameters recommended for Phase I Routine B monitoring to evaluate pollution control systems.

CONSTITUENT (a)	LIQUIDS	GASES
Dissolved Organic Carbon (b)	X	
Oil and Grease	X	
pH	X	
NH ₃	X	X
H ₂ S		X
SO ₂		X
NO _x		X
CO		X
Total Suspended Particulates		X

(a) These parameters will be measured in the wastes marked by an "X" in the Routine B column of Table 4-4. The recommended sampling frequencies are summarized in Table 4-3 under the Routine B column. The analytical methods that will be used to measure each parameter are summarized in Table 4-12.

(b) Dissolved organic carbon is a better performance parameter for complex oil shale waters than chemical oxygen demand (COD) or biochemical oxygen demand (BOD). These more conventional parameters (COD, BOD) suffer from a number of well known analytical problems when used on oil shale effluents (e.g., Fox et al., 1978; Daughton, 1983), and they are not accurate indicators of organic carbon removal.



DESIGN OF PHASE II SUPPLEMENTAL MONITORING PROGRAM

FIGURE 4-3

vtm

Kingsbury 1977). Retort water will be used as the surrogate for liquids, raw and spent shales as the surrogate for solids and retort gas as the surrogate for gases. If the maximum reported concentration in any waste exceeds the published MATE, that parameter will be selected for Routine A monitoring under the Phase I program. The resulting list of Routine A parameters will be modified in Phase II using Phase I data. The MATE approach will only be used for constituents for which no standard exists. If a federal or state standard does exist, the listed standard will take precedence over the MATE.

A MATE is an approximate concentration for contaminants in source emissions to air, water or land which will not evoke significant harmful or irreversible responses in exposed humans or ecology for short duration exposures (less than eight hours per day). MATEs are based on threshold limit values established by the American Conference of Governmental Industrial Hygienists (ACGIH); National Institute for Occupational Safety and Health (NIOSH) maximum concentrations for workroom air; drinking water standards; water quality criteria; radiation regulations; and lethal and toxic dose information from animal studies and from human exposures. Six separate MATEs (for health and ecologic effects from solids, liquids, and gases) have been calculated and compiled for some 600 chemical substances. These MATEs will be reviewed and updated to reflect current knowledge of oil shale materials and extended to include particulates in air. (The MATEs for solids are for solids disposed on the ground and subject to leaching; no MATEs presently exist for air-borne solids.)

It is anticipated that this procedure will yield a reasonable list of unregulated inorganic parameters for Routine A Phase I monitoring. However, there is inadequate information on organics in gaseous, liquid, and solid wastes in the Geokinetics process to use a similar approach. Therefore, the survey analyses, described in the previous section will be the principal source of information on unregulated organic pollutants. These survey analyses will be augmented by

measuring "indicator" parameters during Routine A Phase I. Indicator parameters are representative of broad classes of compounds which may contain toxic and carcinogenic compounds and which are known to be present in oil shale wastes (e.g., organic nitrogen or hydrophobic organic carbon).

Routine B Monitoring. Regulated and unregulated parameters necessary to evaluate the performance of liquid and gaseous pollution control devices will be monitored. The specific parameters depend upon the control technology (described in Section 2.0). The recommended parameters for the Geokinetics process are presented in Table 4-4. In addition, one set of samples taken during normal plant operation will be monitored under the routine A program to assess the ability of pollution control devices to remove unregulated pollutants.

4.2.1.3.2 Selection of Routine A Parameters

Wastes from the Geokinetics process have been studied by the developer and by federally supported research programs at universities and national laboratories since 1976. These data are directly applicable to the proposed commercial-scale 1,000 bpd facility, and they will be used to identify important unregulated parameters. The pertinent data from these research programs are summarized and discussed in the following sections. Characterization data are compared with MATEs to select unregulated parameters for Routine A Phase I monitoring. The results of this analysis are shown in Table 4-7.

Characterization of Solids

Five solids are involved in or will be produced by the Geokinetics process: raw shale, spent shale, sludges, sulfur and fugitive dust. Underground raw shale is blasted to produce fractures in the in-situ shale prior to oil production. All spent shale remains in the

Table 4-7. Parameters recommended for Phase I Routine A monitoring in the supplemental program.

CONSTITUENT (a)	SOLIDS (b)	LIQUIDS (c,d,e)	GASES (c,f)
<u>Inorganics</u>			
Ag		M	
Arsine			M
As		M	M (g)
B		M	
C, inorganic		C	
Ca		M	
Cd		M	
Co		M	
Cl		C	
CN		M	
CO3		C	
Cu		M	
F		M	
Fe		M	
H2S			M
HC03		C	
Hg		M	
K		M	
Li		C, I	
Mg		C	
Mn			
Mo		M	
Na		M	
Ni		M	
NH3		M	M
P		M	
Pb		M	
pH		C	
S2O3		C	
Sb		M	
SCN		C	
Se		M	
SO4		C	
TDS		C	
V		M	
Zn		M	

Table 4-7 (Continued)

CONSTITUENT (a)	SOLIDS (b)	LIQUIDS (c,d,e)	GASES (c,f)
<u>Organics</u>			
Org. C		C	I (g)
Org. C, HPO/HPI		C, I	
Org. N		C, I	I (g)
Org. S		C, I	

(a) These parameters will be measured in the wastes marked by an "X" in the Routine A column of Table 4-4. The recommended sampling frequencies are summarized in Table 4-3 under the Routine A column. The analytical methods that will be used to measure each parameter are summarized in Table 4-12.

(b) Routine A monitoring will not be required on any of the solids. (See discussion in Sec. 4.2.1.3.2, "Solids.") This is because there either is no characterization data on them (and survey analyses will be performed) or existing data are adequate to define baseline conditions. However, several environmentally important elements have not been quantitated in raw and spent shales (B, F, Ag, Hg, Cd, Te). These will be measured in a composite of select existing cores of raw and spent shale.

(c) The following abbreviations and symbols are used in this table:

- C = parameter selected to provide general background chemistry
- M = parameter selected because maximum reported literature concentration exceeds MATE
- I = indicator parameter or environmental tracer (e.g., Li).

(d) This list of parameters will be modified prior to submission of the final monitoring plan. This list is based on retort waters. It will be expanded to include parameters relevant for retort leachates.

(e) The parameters marked with an "M" in this column are taken from the effluent MATE analysis in Table 4-9.

(f) The parameters marked with an "M" in this column are taken from the gas MATE analysis in Table 4-11.

(g) Arsenic, organic nitrogen, and organic carbon are to be measured in gases and particulates in KTI boiler flue gas, incinerator flue gas, and retorting fugitive emissions.

underground environment following retorting. These raw and spent shales may be contacted by local ground waters, which are primarily low quality perched zones of water, or by percolation from precipitation. The resulting impact on local ground waters will probably be minimal as the permeability of geologic formations underlying the retorted region is low and the site is relatively dry (Law 1981, Kaman Temp 1981). The sludges originate from the gravity separator and the thermosludge unit, and sulfur is recovered in Stretford unit. Fugitive dust, which is composed largely of suspended soil material and exhaust particulates, originates from on-site blasting, land clearing, vehicular traffic, and equipment and personnel movement. This dust has been quantitated at several oil shale sites, including the Seep Ridge site (Fox et al. 1982, Hargis et al. 1983), and may have an inorganic composition similar to raw shale.

The most comprehensive investigation of inorganics in shale is the EPA-funded joint study conducted by the Laramie Energy Technology Center (now Wyoming Research Center), the Lawrence Berkeley Laboratory and Colorado State University (Bates 1983). The Final Report from this work is in preparation. In this study, the investigators analyzed 178 samples of spent shale from four cores through Retort 16, and 82 samples of raw shale from a single core outside the boundary of this retort. Mineralogical and elemental composition were determined, and leaching studies were conducted. The inorganic composition of raw and spent shales from this work is summarized in Table 4-8 and compared with MATEs. The major elements in these solids (occurring at weight % level) are Na, Ca, Mg, K, S, N, C, Al, Fe and H.

Selection of Parameters

All of these five solids will be characterized under the survey program. The inorganics and organics in byproduct sulfur, fugitive dusts and sludges will be screened under the survey program prior to selecting routine parameters in Phase II. On the other hand, the inorganics

Table 4-8. Characterization of raw and spent shales from Geokinetics Retort 16 (Giauque, 1983).

CONSTITUENTS	RAW SHALE (a) (ppm)	SPENT SHALE (a) (ppm)
Ag	<2.1	<2.4
Al	1.24% - 6.30%	1.83% - 7.42%
As	3.9 - 62.3	7.5 - 65.5
Ba	377 - 947	473 - 1110
Bi	<2.7	<3.6
Br	<0.9 - 3.6	<1.3
C (inorg)	2.26% - 8.04%	0.03% - 7.79%
C (org)	0.92% - 28.0%	0.02% - 18.29%
Ca	4.7% - 21.4%	7.1% - 24.2%
Ce	17.6 - 62.7	23.2 - 79.8
Cd	<2.7	<2.4
Cl	<0.3%	<0.3%
Co	2.43 - 10.6	3.37 - 19.53
Cr	13.5 - 47.7	19.8 - 52.2
Cs	1.93 - 9.65	2.33 - 10.95
Cu	7.3 - 46.9	8.7 - 98.6
Dy	1.00 - 8.12	1.33 - 10.50
Eu	0.27 - 1.22	0.35 - 1.50
Fe	0.8% - 3.7%	0.97% - 3.63%
Ga	3.4 - 17.8	4.1 - 19.3
Ge	<1.8	<1.8 - 2.5
H	0.26% - 3.44%	<0.05% - 2.56%
Hf	0.73 - 3.52	0.90 - 3.86
Hg	<2.7	<3.0
I	<4.5	<4.5
In	<3.2	<3.2
K	0.68% - 5.08%	0.85% - 5.27%
La	8.1 - 29.7	10.2 - 40.7
Lu	0.09 - 0.40	0.12 - 0.56
Mg	1.74% - 6.61%	2.59% - 6.86%
Mn	173 - 511	249 - 496
Mo	1.4 - 34.6	1.8 - 46.8
N	0.07% - 1.08%	<0.05% - 0.66%
Na	0.68% - 3.18%	0.81% - 4.11%
Nb	2.2 - 11.6	2.6 - 11.2
Nd	7.6 - 25.5	9.7 - 43.4
Ni	9.2 - 28.1	9.7 - 53.5
Pb	3.3 - 39.7	3.3 - 67.5
Pd	<2.1	<2.1
Rb	28.5 - 127.0	28.7 - 132.0
Rh	<2.1	<2.1

Table 4-8 (Continued)

CONSTITUENTS	RAW SHALE (a) (ppm)	SPENT SHALE (a) (ppm)
S	<0.05% - 1.18%	<0.05% - 0.84%
Sb	0.37 - 3.28	0.46 - 4.55
Sc	2.59 - 9.40	3.10 - 10.30
Se	0.7 - 2.6	0.3 - 2.3
Sm	1.27 - 6.51	1.60 - 8.71
Sn	<3.3 - 14.8	<3.0
Sr	288 - 1370	444 - 1510
Ta	0.170 - 0.942	0.215 - 1.004
Tb	0.151 - 1.16	0.194 - 1.48
Te	<3.9	<3.9
Th	2.5 - 16.4	3.46 - 14.18
Ti	0.06% - 0.25%	0.06% - 0.24%
U	2.66 - 8.73	2.14 - 8.56
V	48 - 155	42 - 272
W	<4.0	<4.0
Y	3.3 - 46.3	8.9 - 56.6
Yb	0.58 - 3.97	0.76 - 4.84
Zn	20.8 - 116	12.9 - 96.3
Zr	25 - 141	34.2 - 166

(a) Ranges for raw shale are for core 16-22, and ranges for spent shale are for core 16-11.

in raw and spent shales have been extensively characterized, and no additional inorganics characterization of these two solids is recommended (Krause 1980, Mason and Sinks 1982, Giauque 1983). (This will be elaborated upon in the following paragraphs.) However, the organics in raw and spent shales have not been extensively studied, and these will be characterized under the survey program in Phase I.

No further inorganic characterization of raw and spent shales is required for the following two important reasons. First, the exposure of raw and spent shale to the environment is through the leaching process. The solids themselves are fully contained, and they do not interact with the environment except through the leaching process. Retort leachates are fully characterized under the supplemental program (see the section on "Liquids"). The solids are the source for the leachates and as such, they already have been adequately characterized for inorganics. Thus, Routine A monitoring of inorganics in these wastes is not required (Table 4-4). In fact, several studies have demonstrated that major, minor and trace elements in oil shales are uniform laterally and vary only with depth in the formation (e.g., Giauque et al. 1980, Tuttle et al. 1983). Since the vertical position of Geokinetics retorts and retort operating conditions for the proposed facility will be similar to those in Retort 16, the chemical composition of the raw and spent shales will be very similar to those from Retort 16 used in the EPA study.

However, some environmentally important elements either have not been measured at all (B, F), or they are below the detection limits of the methods used and have low MATEs (Ag, Hg, Od, Te). These elements should be quantitated in a composite of one of the cores used in the EPA study. No additional coring is required since the extensive existing data on Geokinetics retorts is representative of other areas at the Seep Ridge site.

Organic characterization data are inadequate for raw and spent shales and should be developed by analyzing the same cores used in the EPA study. A single core of both raw and spent shale should be composited over the core length and a single composite sample analyzed for organics using methods described in Section 4.2.1.4.

Characterization of Liquids

Several process effluents will be produced by the Geokinetics process, including retort water, condensates, stripper overheads and bottoms, and plant steam. All of these are derived from retort water via various treatments, and under normal conditions, they are completely contained in closed systems and are not exposed to the environment (except via steam vents). Only the evaporation pond contents (primarily retort water) require survey and routine monitoring. The other effluents will be monitored for broad characterization under the survey program to evaluate pollution control performance (Table 4-4). One sample of each contained effluent will be monitored under the Routine A program to assess the ability of pollution control systems to remove unregulated pollutants.

The principal effluent from the Geokinetics process is retort water which is produced in about a 1:1 ratio with the oil (875-1,300 bpd per 1,000 bpd of oil). Under normal operating conditions, the retort water will undergo gravity separation followed by steam stripping. Stripper bottoms will be processed in the thermosludge unit, and stripper overheads will be incinerated. During upset conditions, the untreated retort water and/or the steam-stripped retort water will go directly to the evaporation pond in Area 5000. This pond also will be used to provide surge capacity. Outflow from the pond will be recycled to the plant.

The plant steam produced by the thermosludge unit may contain some volatile organics and inorganics (e.g., ammonia and pyridines) which

originally were present in the retort water. These may be released into the plant air at various vents, and they may lead to corrosion and subsequent leaks. Thus, this steam will initially be characterized.

The inorganic composition of untreated retort water, and evaporation pond contents, is well known and has been reported by both Geokinetics and several research laboratories. The inorganic composition of retort waters and evaporation pond waters is summarized in Table 4-9 and compared with MATEs. These waters are alkaline and have high dissolved solids. The principal anions are HCO_3 , CO_3 , S_2O_3 , SCN , Cl and SO_4 , and the principal cations are Na and K . Several trace elements are elevated and exceed MATEs for ecological or health impacts, including Ag , As , Cd , B , Co , F , Hg , Mo , Ni , Se and Sb .

Much less is known about the organic composition of Geokinetics retort water, and survey analyses will be used to identify those compounds of concern. Several investigators have reported partial analyses of a limited number of samples of retort water. More extensive characterization work is in progress at Los Alamos Scientific Laboratory, and results will be available in several months (Spall 1983).

Fish et al. (1982) analyzed the carboxylic acids in a sample of retort water from Geokinetics Retort 16. They found straight-chain monocarboxylic acids (C_2 - C_{10}) and di-carboxylic acids (C_3 , C_4 , C_8 - C_{11}); branched carboxylic acids (e.g., 2-Methylpentanoic acid); and aromatic carboxylic acids (e.g., benzoic acid and 3-Methylbenzoic acid) at individual compounds concentrations of between 0.1 and 14 ppm. These concentrations are well below published MATEs. In other work, Fish (1980) reported the identification of several phenols (e.g., phenol, 2-Methylphenol, Dimethylphenol isomers) and aliphatic cyclic ketones (e.g., cyclopentanone) in water from Retort 16.

Rinaldi et al. (1981) reported organic priority pollutants detected in retort water and evaporation pond water from Retort 17. These data are

Table 4-9. Characterization of retort water and evaporation pond water from the Geokinetics process.

CONSTITUENT	RANGE (a) (mg/l)	MATE (b) (mg/l)	ROUTINE MONITORING REQUIRED (c)
<u>Inorganics</u>			
Ag	0.026 - 0.13	0.005	X
Al	0.1 - 0.51	1.0	
As	1 - 15.0	0.05	X
B	28 - 186	25	X
Ba	0.22 - 0.5	2.5	
Be	<0.005	0.03	
Br	0.2 - 0.7	-	
C (inorg)	1994	-	
Ca	0.4 - 25	16	X
Cd	<0.009 - 0.1	0.001	X
Ce	<0.02	550	
Cl	117 - 150	1300	
CN	1.4 - 266	0.025	X
Co	0.065 - 0.8	0.25	X
COD	3734 - 10,900	-	
CO3	178 - 345	-	
Cr	<0.02 - 0.06	0.25	
Cu	0.04 - 0.4	0.05	X
F	16 - 42	30	X
Fe	0.6 - 15	0.25	X
Ge	0.06	8.4	
Gross Alpha, pc/l	7.3	-	
Gross Beta, pc/l	265	-	
HCO3	5380 - 13,972	-	
Hg	0.001 - 0.04	0.001	X
I	0.2	-	
K	29 - 113	23	X
Li	0.02 - 0.32	0.33	
Mg	7.6 - 31.0	87	
Mn	0.01 - 0.08	0.1	
Mo	0.2 - 10.6	7.0	X
Na	2800 - 8521	30	X
NH3 - N	738 - 2310	0.05	X
Ni	<0.1 - 4.0	0.01	X
NO3 - N	<0.01	-	
P	0.29 - 1.5	0.0005	X
Pb	<0.02 - 0.8	0.05	X
pH	8.62 - 8.9	-	
Rb	1.9	1800	
S	360 - 4170	-	
Sb	0.051 - 0.44	0.2	X
SCN	325 - 1025	-	
Se	0.02 - 0.4	0.025	X
Si	0.31 - 57	150	

Table 4-9 (Continued)

CONSTITUENT	RANGE (a) (mg/l)	MATE (b) (mg/l)	ROUTINE MONITORING REQUIRED (c)
<u>Inorganics</u>			
SO ₄	825 - 3075	-	
Sn	0.05 - 0.10	-	
Sr	0.004 - 0.89	46	
S ₂ O ₃	<25 - 140	-	
TDS	9400 - 28,400	-	
Th	<0.01	6.3	
Ti	0.02 - 0.26	0.82	
Tl	<0.01	1.5	
U	0.038 - 0.2	0.5	
V	<0.05 - 0.6	0.15	X
W	<0.5	15	
Zn	0.05 - 0.65	0.1	X
<u>Organics</u>			
Org C	1904 - 2140	-	
Org C, HPO/HPI	498 / 1148	-	
Org N	50 - 355	-	

- (a) The range is for several samples of retort water and evaporation pond water from retorts 9, 12, 14, 16, and 17 as reported by Geokinetics (1979); Ahern et al. (1982); Wilkerson (1982); Rinaldi et al. (1981); and Daughton (1982).
- (b) The reported value is the most stringent Minimum Acute Toxicity Effluent (MATE) value for health or ecological effects as reported by Cleland and Kingsbury (1977).
- (c) An "X" in this column indicates that the concentration reported in the range column exceeds the MATE. These constituents are recommended for monitoring in the Routine A Program. They are indicated by an "M" in the liquids column of Table 4-7.

summarized in Table 4-10. The only priority pollutants which exceed published MATEs are phenol, acrolein and acrylonitrile. Because these are the only analyses ever reported for priority pollutants in Geokinetics waters, it is recommended that they not be monitored in the Routine A program. Additional supporting data will be developed by survey monitoring prior to including these three constituents in the routine program.

In addition to these process effluents, other retort leachates may be indirectly generated by the Geokinetics process. Localized, on-site ground waters may be contaminated by the migration of retorting products (e.g., gases). Precipitation, particularly winter snowfalls, may percolate through abandoned retorts and eventually reach shallow subsurface zones of ground water. These concerns have been and are presently being investigated at the Seep Ridge site, and it is expected that this work will continue. Some of the data from this program has been published (Geokinetics 1982). Similar studies will be conducted in the vicinity of the proposed facility. Wells will be installed outside of the retort-area and retort leachates will be characterized by collecting pre-, during- and post-burn ground water samples.

Selection of Parameters

The characterization data presented above can be used to select Routine A parameters. Those parameters listed for effluents on Table 4-10 which are not subsequently regulated by permit, will be monitored in the supplemental program. The parameters shown on Table 4-7 were derived by comparing retort water concentrations with MATEs for liquids (Table 4-9). Since retort leachates may have a different chemical composition than retort waters, the MATE analysis reported in Table 4-9 for retort water will be repeated using actual leaching data from Colorado State University (Bates 1983) and from the Geokinetics field investigations (Geokinetics 1982). These data were not available in time to prepare the monitoring plan. Thus, the list of parameters for

Table 4-10. Organic priority pollutants in Geokinetics effluent samples (Rinaldi et al., 1981). (a)

COMPOUND	CONCENTRATION, ug/L	
	RETORT WATER	EVAPORATION POND WATER
Acids:		
Phenol	670	230
Base/Neutrals:		
Acenaphthylene	11	92
Anthracene and phenanthrene	3.6	10
Chrysene	- (b)	0.9
Fluoranthene	-	8.3
Pyrene	-	3.2
Direct injectables:		
Acrolein	-	360
Acrylonitrile	250	1,700
Volatiles:		
Benzene	370	67
Chloroform	-	2.0
Ethylbenzene	45	29
Methylene chloride	11	22
Tetrachloroethylene	0.9	0.5
Toluene	280	64

(a) Compounds not listed here, if present, were at concentrations below detection limits or were not significantly greater than the system blank.

(b) A dash indicates that, if present, the compound was at a concentration below its detection limit.

effluents shown in Table 4-7 will be expanded to include parameters unique to retort leachates.

The volume and quality of inorganic data are adequate to select Routine A parameters for retort leachates and evaporation pond contents. The existing data on organics is inadequate to select specific unregulated compounds for Routine A monitoring, and thus data will be supplemented by performing organic survey analyses on evaporation pond contents and plant steam (Table 4-4). The compound classes selected for these analyses (Table 4-5) are based on those found in other oil shale retort waters (e.g., Spall 1982).

Characterization of Gases

Several gaseous streams will be released from the Geokinetics process, including KTI boiler flue gas, incinerator flue gas and power generation flue gas. All of these are derived from retort gas via various treatments, including sulfur and ammonia removal and incineration. Although these gases will be upgraded to comply with ambient air standards, they may contain environmentally important trace constituents which are not regulated. Other gas streams are completely contained, including raw retort gas, absorber offgas and sulfur removal gas, and they are not exposed to the environment. Most of the discharged gases have not been characterized previously, and survey and routine monitoring will be performed (Table 4-4) on them.

The principal gas stream from the Geokinetics process is retort gas. Under normal conditions, ammonia and hydrogen sulfide are removed, and the treated gas is used for power generation or is incinerated. Gas leakage through the fractured overburden and well casings also has been reported (Rinaldi et al. 1983, Geokinetics 1982) and partially characterized (Hargis et al. 1983). The composition of this vented gas should be similar to untreated retort gas (some constituents will adsorb onto overburden material). Studies during the burning of

Retort 24 (Hargis et al. 1983) indicated that ambient concentrations of all gases measured were below established threshold limit values in breathing zones above the retort. High concentrations of select species were observed around the offgas blower, the demister, and a leaking fan, indicating that careful maintenance of offgas handling equipment will be required.

The composition of retort gas from several experimental Geokinetics retorts has been reported (Rinaldi et al. 1981, Geokinetics 1982). The gas handling system used in these retorts differed significantly from that proposed for the 1,000-bpd facility, and thus, much of this characterization data is not directly applicable to the proposed facility. The experimental retort gas handling system consisted of a demister to remove oil vapor and an incinerator. The only comparable gas stream in the commercial facility is the raw retort gas (inlet to demister).

The published data on various gas streams from Geokinetics' retorts are summarized in Table 4-11. The majority of this data is from a field sampling program conducted by Monsanto (Rinaldi et al. 1981). Geokinetics also has routinely measured the retort and stack gases for hydrocarbons, NH_3 , H_2S , COS and several other constituents. Although some of this data has been published in Annual Reports to DOE (e.g., Geokinetics 1982), it has not been reduced and summarized for use in environmental analysis. These data will be reduced and analyzed to help develop the supplemental program when the final monitoring program is submitted.

The data in Table 4-11 and other data published by Geokinetics (1982) reveal that the major gaseous species are carbon dioxide, carbon monoxide, C1-C6 hydrocarbons, ammonia and hydrogen sulfide. Gaseous species which exceed reported MATEs are ammonia, hydrogen sulfide, arsine and total arsenic. Particulate concentrations are below reported MATEs for all elements except As.

Table 4-11. Characterization of demister inlet and outlet and incinerator gases from Geokinetics Retort 17 in ug/m3. (a,b)

CONSTITUENT	DEMISTER INLET	DEMISTER OUTLET	INCINERATOR OUTLET	MATE (c)	ROUTINE MONITORING REQUIRED(e)
GASEOUS					
<u>Inorganics</u>					
NH ₃ , mg/m ³	170-2000 (d)	890	0	18	X
AsH ₃	5	9	-	2	X
As	130	38	0.4	2	X
Cd	1.0	1.2	0.9	10	
Pb	18	10	20	150	
Hg	1.4	2.7	0.2	10	
Se	ND	0.5	4.2	200	
H ₂ S	540-2660 (d)	-	-	15	X
COS		-	-	440	
<u>Organics</u>					
HCN	3200	4300	7	11,000	
Benzene	D	D	ND	3,000	
Toluene, mg/m ³	53	230	1	375	
C3-C10 alkanes	D	D	ND	-	
C4-C6 alkenes	D	D	ND	-	
C2 benzenes, mg/m ³	110	240	ND	-	
C1-C3 cyclohexanes	D	D	ND	-	
C3 cyclohexanes, mg/m ³	110	240	ND	-	
C3-C10 aliphatics, mg/m ³	470	880	ND	-	
PARTICULATE					
<u>Inorganics</u>					
As	40	-	140	2	X
B	280	-	<1	3,100	
Ca	80	-	<0.04	16,000	
Co	2	-	10	50	
Fe	50	-	<2	1,000	
Pb	50	-	<23	150	
Mo	2	-	<11	5,000	
K	260	-	-	-	
Se	5	-	10	200	
Na	720	-	<27	53,000	
Sn	110	-	320	-	

(a) Modified from Rinaldi et al. (1981).

(b) The following symbols are used in the table: ND = not detected; D = detected but not quantitated; - = not measured or no MATE reported.

(c) From Cleland and Kingsbury (1977).

(d) Modified from Geokinetics (1982).

(e) An "X" in this column indicates that the concentration reported in the range column exceeds the MATE. These constituents are recommended for monitoring in the Routine A Program. They are indicated by an "M" in the gas column of Table 4-7.

This existing data and published MATEs for particulates are inadequate to select unregulated parameters for routine monitoring. Survey analyses will be used to develop a more comprehensive data base to select unregulated gaseous and particulate pollutants for Phase II monitoring. The parameters shown to exceed MATEs in Table 4-11 will be monitored in the Routine A program.

4.2.1.4 Analytical Methods

The analytical methods proposed for Phase I monitoring of unregulated pollutants are summarized in Table 4-12.

4.2.1.4.1 Survey Monitoring

In the survey program, liquids and solids for which there are inadequate data will be analyzed by spark source mass spectrometry (SSMS) and gas chromatography/mass spectrometry (GC/MS) and screened for biological activity. Liquids include effluents and impinger solutions (used to trap gaseous species), and solids include solid wastes, particulates and charcoal used to adsorb gaseous trace elements. In addition, x-ray fluorescence spectrometry (XRF) will be used on at least one sample of each type (solids only) to assess accuracy of SSMS.

SSMS has been widely used for screening oil shale wastes (Poulson et al. 1977, Gebhart and McKown 1982), and there are commercial laboratories in the Rocky Mountain region that have experience in applying this technique to oil shale wastes. This technique allows simultaneous determination of approximately 80 elements in most solid and liquid samples with a minimum of matrix effects, spectral overlap or inter-element interferences. Solid and liquid samples do not have to be ashed or digested prior to analysis, and typical detection limits for most elements are in the 50 to 100 ppb range. Precision typically is 50% or less for most elements.

Table 4-12. Analytical methods that will be used in the supplemental monitoring program.

METHOD (a)	WASTE STREAMS	PARAMETERS (a,f)
<u>SURVEY ANALYSES (b)</u>		
<u>Inorganics</u>		
SSMS	liquid effluents impinger solutions solids particulates charcoal adsorbent	Ag, Al, As, Au, B, Ba, Be, Bi, Br, Ca, Cd, Ce, Co, Cr, Cs, Cu, Dy, Er, Eu, F, Fe, Ga, Ge, Gd, Hf, Hg, Ho, I, In, Ir, K, La, Li, Lu, Mg, Mn, Mo, Na, Nb, Nd, Ni, Os, P, Pa, Pb, Pt, Pr, Rb, Re, Rh, Ru, S, Sb, Sc, Se, Si, Sm, Sn, Sr, Ta, Tb, Te, Th, Ti, Tl, Tm, U, V, W, Y, Yb, Zn, Zr
XRF	solids particulates charcoal adsorbent	Ag, Al, As, Ba, Br, Ca, Cd, Cl, Co, Cr, Cu, Fe, Ga, Hg, K, In, La, Mg, Mn, Mo, Na, Ni, P, Pb, Pd, Rb, S, Sb, Se, Si, Sn, Sr, Ti, V, Y, Zn, Zr
<u>Organics</u>		
GC/MS	extracts of liquids, solids, particulates, and adsorbents used to trap trace organics in gases	major volatile and semivolatile organic compounds in each of the following classes: benzenes, indans, indenenes, naphthalenes, benzoic acids, aldehydes, ketones, phenols, furans, nitriles, amines, pyrroles, pyridines, quinilines, and thiophenes priority pollutants
Ames Assay	liquid effluents extracts of solids, liquids and adsorbents	mutagenicity
<u>ROUTINE A ANALYSES (c)</u>		
ICPES	liquid effluents	Ag, V, Cd, Pb, Sb, Na, K, Mg, Ca, Ni, Cu, Zn, B, As, Se, Fe, Mo, Co, P
Ion chromatography	liquid effluents	CN, S2O3, SO4, F, Cl, CO3, HCO3, SCN, Li, K, Mg, Ca, Na
<u>Standard Methods</u> (e)	liquid effluents	inorganic C, NH3, pH, TDS, organic C, organic N, HPO/HPI carbon

Table 4-12 (Continued)

METHOD (a)	WASTE STREAMS	PARAMETERS (a,f)
Indicator tubes or on-line GC	gases	H ₂ S, NH ₃
Adsorption onto charcoal or a resin followed by AA hydride generation analysis	gases particulates	As
Impinger train	gases	Arsine
Methods presently undetermined	liquid effluents solids	Hg, Organic S
<u>ROUTINE B ANALYSES (d)</u>		
<u>Standard Methods</u> (e)	liquid effluents	Organic C, oil and grease, pH, NH ₃
EPA Methods	gases	NH ₃ , H ₂ S, SO ₂ , NO _x , CO, TSP

(a) Abbreviations used in this table are:

AA = atomic absorption spectroscopy
 SSMS = spark source mass spectrometry
 XRF = x-ray fluorescence spectrometry
 ICPES = inductively coupled plasma emission spectrometry
 GC/MS = gas chromatography/mass spectrometry
 HPO = hydrophobic organic carbon
 HPI = hydrophilic organic carbon
 TSP = total suspended particulates

(b) These analytical methods are discussed in Section 4.2.1.4.1. The parameters listed in the last column are the same as those summarized in Table 4-5 for survey monitoring.

(c) These analytical methods are discussed in Section 4.2.1.4.2. The parameters listed in the last column are the same as those summarized in Table 4-7 for Routine A monitoring.

(d) The parameters listed in the last column are the same as those summarized in Table 4-6 for Routine B monitoring.

(e) Modifications of the Standard Methods reported by Daughton (1982) and Persoff et al. (1983) are recommended for organic C and inorganic C, NH₃, organic N, and hydrophobic (HPO) and hydrophilic (HPI) carbon.

(f) Many of these elements (e.g., Er, Os, Pa, Pr) have not been detected and are not suspected to be present in oil shale wastes. All of them are simultaneously measured by the analytical method selected for measurement.

XRF has been widely used to measure oil shale solid wastes (Fox 1980, Fruchter et al. 1981, Fox et al. 1980). Extensive evaluations show that it yields very precise and accurate results when applied to solid oil shale wastes (Fox et al. 1980). The technique is commercially available in a number of laboratories. XRF typically measures 30 to 40 individual elements simultaneously by bombarding a pulverized and compressed sample or a filter with radiation and measuring the intensity of emitted radiation. It will be used quality control survey monitoring of most trace elements in solids and particulates.

Organic priority pollutants and other volatile to semivolatile organic compounds will be determined in liquids, solids and gases using GC/MS. One or more major compound(s) and priority pollutants from each chemical class shown in Table 4-12 will be determined. The specific compounds that will be measured will be selected from previous organic characterization studies of Geokinetics wastes (Spall 1983) and other similar oil shale wastes.

This technique has been extensively used to characterize organics in oil shale wastes (Gebhart and McKown 1982, Sklarew et al. 1981, Cotter et al. 1978, Raphaelian and Harrison 1981, Ondov et al. 1982), and the analyses can be performed at many commercial laboratories. Liquids and solid samples will be serially extracted at acidic and basic pHs with methylene chloride and the extracts pooled, concentrated and dried. Gases will be collected by adsorption onto Tenax GC or XAD-2 resins, eluted with normal pentane, concentrated and evaporated, and directly analyzed by GC/MS. Organic compounds will be identified by manual and computer-assisted matching of molecular fragmentation patterns of observed pollutants with those of standard compounds. Concentrations will be estimated from peak areas using calibrated FID response factors, sample volumes and solvent dilution factors.

Because of the chemical complexity of these wastes and the limitations of conventional analytical methods to identify all potentially important compounds, biological testing will be used on select samples to

detect the presence of mutagens, teratogens and carcinogens. The Ames Assay will be used in the survey program. The results from this Ames Assay will be reviewed by the Health and Safety Program Administrator.

The Ames Assay is commonly used to detect mutagens in food, drinking water, chemicals, commercial products and a host of other materials. It also has been extensively evaluated for detecting mutagens in Geokinetics wastes (Meyne and Deaven 1981, Strniste and Chen 1981, Holland and Stafford 1981), and it has been found to be a very sensitive indicator of mutagenicity. The Ames Assay will be used on two samples of each liquid effluent, solid waste, adsorbent (for gaseous trace organics analysis), and particulates (from gaseous streams) in the survey program. Gases will not be directly assayed due to sampling limitations.

4.2.1.4.2 Routine A Monitoring

Elemental abundances can be determined in solids by x-ray Fluorescence Spectrometry (XRF) and in liquids by Inductively Coupled Plasma Emission Spectrometry (ICPES). Anions and cations will be determined by ion chromatography. All of these techniques have been validated for oil shale wastes and demonstrated to be both precise and accurate for most constituents (Fox et al. 1980, Fox 1980, Peterson et al. 1982, McFadden and Garland 1979, Meglen et al. 1982). They also are relatively inexpensive and commercially available.

ICPES can be used to determine individual elements or up to 20 elements simultaneously. Most commercial instruments come with several cassettes which act as optical masks that allow only certain atomic emission wavelengths to impinge on the photomultiplier tubes. Each cassette can simultaneously measure up to 20 individual elements, and detection limits of 1 to 5 ppb are possible for many elements (Mg, Sb, Cd, Pb, Si, Mn, Ca, Sr, Ba, Na, Al, Mo, Li, Be, Zn, Co. Precision is typically less than 10%. This technique will be used for Routine A monitoring of most of the trace elements in liquid effluents.

Ion chromatography (developed since 1975) is being used in many laboratories to measure anions and cations in oil shale wastes (Meglen et al. 1982, McFadden and Garland 1979, Geokinetics 1982). The method uses classical ion exchange principles to separate species, which are quantified by their conductivity as they emerge from the column. Since the species are separated prior to analysis, this method is less susceptible to the chemical interferences that plague standard wet chemical techniques. The technique also essentially simultaneously analyzes several species, reducing analytical time and cost compared to analysis by Standard Methods. This technique will be used to monitor sulfur species, CN, F, Cl and carbonate species in liquid effluents.

The presence of organic substances will be routinely monitored using the indicator parameters organic nitrogen, organic sulfur and hydrophobic (nonpolar) and hydrophilic (polar) organic carbon. These general organic fractions, particularly hydrophobic organic carbon and organic nitrogen, contain the majority of the biologically active compounds (Toste et al. 1982, Spall 1982). The organic carbon fractions will be measured using a technique developed by researchers at the Lawrence Berkeley Laboratory (Daughton 1982). The sample is fractionated into hydrophobic and hydrophilic components using a very simple, rapid and inexpensive reverse-phase chromatographic technique. Organic nitrogen will be determined by a pyrochemiluminescence technique (Persoff et al. 1983), and the sulfur method has yet not been chosen.

4.2.1.5 Quality Control

Because of the chemical complexity of many oil shale wastes and the limitations of commercially available analytical methods, it is important to be able to assess the accuracy of measurements. This is provided for in the proposed program by using alternative methods to analyze the same sample and by running different dilutions on a limited number of samples. For example, in addition to duplicate samples and

serial dilutions, "spiked" samples and inter-laboratory comparisons on random samples will be conducted for QA purposes.

The survey and routine programs use different analytical techniques to measure many of the same parameters. At least 10% of the survey and routine measurements will be made on the same sample to provide a check on accuracy. This will be achieved by collecting large-volume composite samples at selected intervals and aliquoting them prior to shipment to analytical laboratories. If serious (greater than 50%) discrepancies in analyses from two techniques are noted, an effort will be made to identify its source and substitute an alternate method.

Trace elements in gases represent the most difficult collection problem due to the complex sample matrices (high organic background and low trace element concentrations). This is being addressed by collecting at least 10% of the samples from the survey program by two separate methods: impinger trains and coconut charcoal.

Many of the liquid samples included in this program are subject to chemical and other interferences. The occurrence of these types of problems can be assessed by running serial dilutions of a sample. If the concentration changes as a function of dilution, an interference is present. The serial dilution techniques will be used on at least one sample of each type of liquid effluent early in the analysis program. If serious analytical problems are detected, an effort will be made to substitute a more accurate method.

4.2.2 Phase II Monitoring

The purpose of the second-phase program is "to limit the scope of monitoring in a manner which will provide data on those substances which are of significant environmental or health concern, while reducing monitoring costs." This will be accomplished by analyzing the Phase I data using techniques described here. It is anticipated that this will

lead to modification in parameters measured, sampling sites, sampling frequency and analytical methods.

This section describes the procedure that will be used to select sampling frequencies, points, and methods; parameters; and analytical methods for Phase II monitoring. The relationship of the Phase I program to the Phase II program was summarized in Figure 4-1. The method that will be used to design the Phase II program is summarized on Figure 4-3.

The Phase I survey and routine monitoring data will be analyzed, and a preliminary Phase II program will be developed. This preliminary program will be carried out for three to six months. The resulting data will be analyzed to evaluate the efficacy of the preliminary Phase II program. If necessary, additional modifications will be made in the preliminary Phase II program following this analysis.

4.2.2.1 Sampling and Analytical Methods

The data collected in the Phase I and preliminary Phase II monitoring programs will be analyzed using pattern recognition techniques to improve the information feedback loops labeled 1 and 2 on Figure 4-1. This technique, discussed by Meglen and Erickson (1981), will be used to evaluate sampling frequencies, number and location of sampling sites, adequacy of analytical techniques and parameter selection. Based on this analysis, and some general considerations discussed below, the Phase I and preliminary Phase II monitoring frequencies, sampling sites, analytical methods and parameters will be modified to produce a final Phase II monitoring program.

Sampling frequency will be modified to reflect the variability in each waste observed in the Phase I program. Highly variable wastes will be monitored more frequently than those which are relatively uniform over time. Otherwise, the considerations discussed in Section 4.2.1.1.2 or the results of the pattern recognition analyses will be followed.

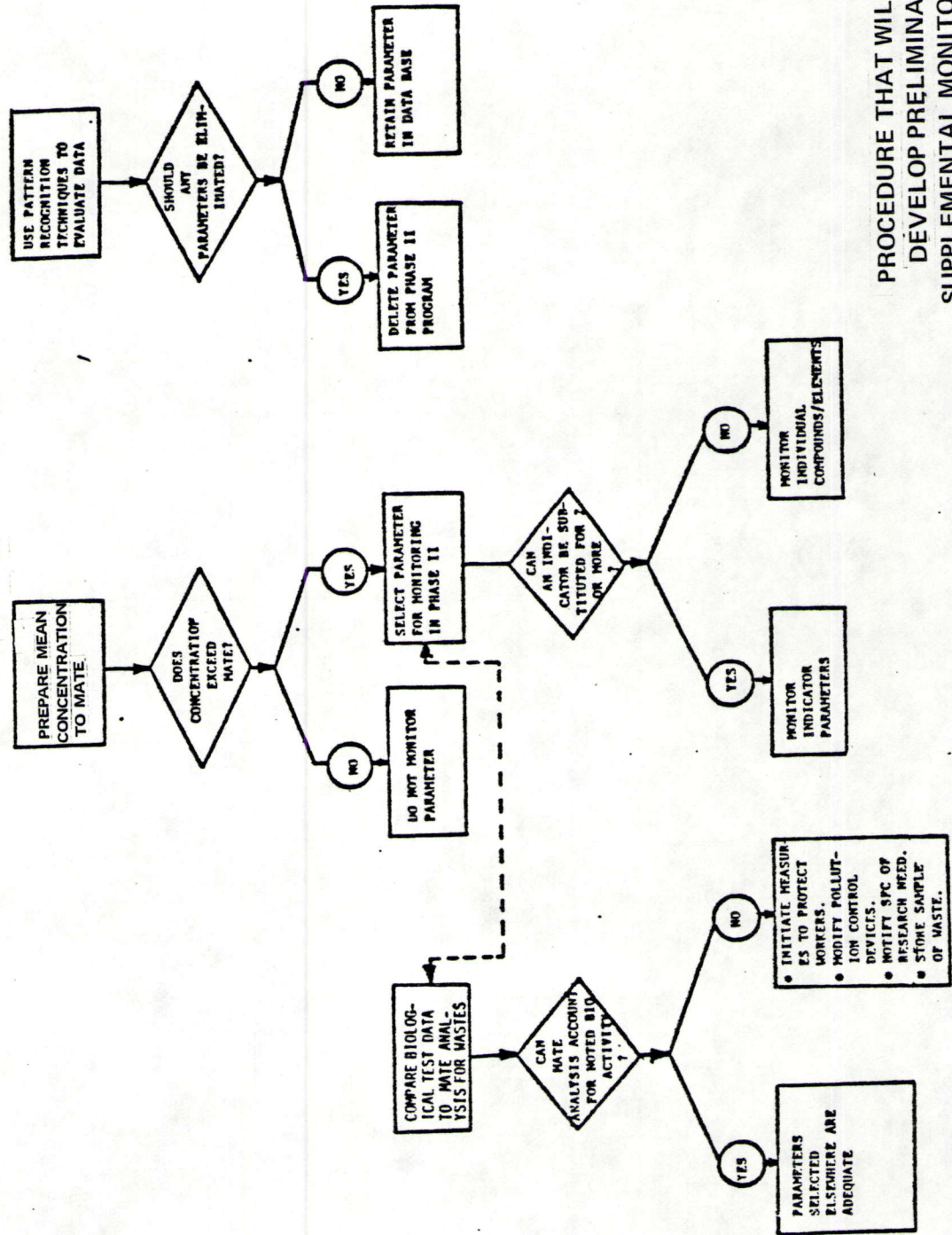
The number of sampling sites will be reduced. Wastes that have no biological activity and which contain no pollutants of environmental or health concern will not be monitored in Phase II. Some sampling sites used only to evaluate control technology performance will be eliminated.

There also will be a shift from analytical methods that are capable of multi-element and multi-compound analysis to those which perform single element or compound analysis. The new methods will be selected to optimize accuracy, precision and cost.

4.2.2.2 Parameter Selection

The general procedure used to identify preliminary Phase II parameters which are of significant environmental or health concern is summarized in Figure 4-4. Briefly, the mean concentration of each element and compound for normal, start-up, shutdown and upset conditions will be compared with MATEs for solids, liquids and gases. If the mean concentration exceeds the MATE for health or ecological impacts, that parameter will be selected for preliminary Phase II monitoring. Prior to this analysis, the MATEs compiled by Cleland and Kingsbury (1977) will be updated and expanded to incorporate recent regulatory changes (i.e., FR, November 29, 1980, p. 79318, Water Quality Criteria) and advances in knowledge. The results of the MATE analysis will be reviewed by the Occupational Health and Safety program administrator to assess uniformity. Pattern recognition techniques also will be used to determine if the number of parameters selected in the MATE analysis can be reduced without sacrificing information content (Meglen and Erickson 1981). The MATE and pattern recognition analyses will be repeated following three to six months of preliminary Phase II monitoring to validate the new program.

Because of the chemical complexity of the samples and the general lack of adequate toxicological data on many of the compounds present,



PROCEDURE THAT WILL BE USED TO
DEVELOP PRELIMINARY PHASE II
SUPPLEMENTAL MONITORING PROGRAM

biological testing will be required. The biological testing data, used to identify the presence of other important compounds not recognized in the physico-chemical analyses will be compared with the MATE analysis. The presence of unidentified pollutants will be indicated if the MATE analysis cannot account for the noted biological activity of a waste. This type of occurrence falls in the domain of research, and it is beyond the scope of commercially available analytical facilities to identify and monitor the specific constituents responsible. In these cases, Geokinetics shall notify the SFC and its consulting agencies of the existence of potential health or environmental concern and recommend that it be pursued in their extramural or other research activities. Geokinetics also will take measures to protect workers, the public and the environment from any harmful effects, including but not limited to the use of protective clothing and respirators.

This general procedure for selecting unregulated parameters for monitoring in Phase II will be supplemented by the use of indicator parameters. The indicator parameter approach involves the use of one or more compounds or elements that are representative of a broad class of compounds. This is particularly suited to organic pollutants since these generally occur as homologous series (e.g., Fish et al. 1982) in oil shale wastes. Rather than monitoring an entire series of compounds, a single environmentally important compound from a class of such compounds occurring at high concentrations will be selected for monitoring. For example, pyridine or an alkylpyridine may be selected as the indicator for pyridines while phenol or cresol may be selected as the indicator for phenols.

4.2.2.3 Quality Control

The quality control program described in Section 4.2.1.5 for Phase I monitoring also will be employed during Phase II monitoring. Modifications will be incorporated to reflect what was learned in the Phase I program.

SECTION 5.0

HEALTH AND SAFETY MONITORING

The Geokinetics Seep Ridge Project Health and Safety Monitoring Program outlined herein consists of: a) a description of health and safety monitoring that addresses the worker environment relative to construction, operation and post-operation phases of the project; b) medical surveillance monitoring including an employee health registry, and c) medical facilities and personnel to support the health monitoring program.

This occupational health plan will not discuss OSHA or MSHA type safety plans since these deal with well-defined activities and/or the use of regulated materials (explosives, acids, etc.).

5.1 Analysis of Health Hazards/Employee Exposure Monitoring

The Geokinetics shale oil production facility in Utah utilizes a serial/sequential activity which consists of essentially three distinct steps (i.e., construction, operation and reclamation). Drilling, blasting, instrumentation and initial ignition of the shale stratum is referred to as construction which utilizes conventional techniques to safeguard workers from occupational health hazards. The operation step refers to retorting and extracting oil from shale and the waste stream treatments. Reclamation is the final step in the Geokinetics operation scheme, which involves conventional techniques for earth moving and revegetation.

All three steps of the oil production activity are sequential, but may occur concurrently in adjacent areas. Thus, area wide occupational health hazards may be present, which affect workers not directly engaged in any particular step, but who are in close proximity to some operating system which is the source of the material of concern.

The separation of the in-situ shale oil production scheme into three distinct steps allows the health and safety monitoring program to focus on the sampling, analyses, mitigation and data collection protocols required to produce a cost-effective plan for safeguarding the health of employees.

5.1.1 Health and Safety Monitoring During Retort Construction Activities

Depending upon the local geology/mineralogy of the overburden materials, the occurrence of asbestos-like fibrous minerals and free silica are of concern to employee's occupational health. Existing mineralogic data (Giauque 1983) will be reviewed to determine the need for special monitoring precautions during the construction step.

5.1.2 Health Monitoring During Retort Operations

This occupational health program deals mainly with employee exposure to solid, liquid or gaseous chemicals which exist in an area and result from a relatively continuous emission source. Retort operations provide some opportunity for employees to be exposed to potentially hazardous or suspect materials. Because retort operations consist of several complex activities, this occupational health plan will employ the same nomenclature and sequencing used by Geokinetics in their process flow sheet (Figure 2-1).

5.1.2.1 Underground Ignition and Continued Burning

Each employee who works near a retort (burning section) will have data accumulated for his work day exposure to fugitive gases, vapors, mists and aerosols which may escape the ground above the burning shale stratum and from leaks at pumps, valves, etc. Fugitive emissions will be collected in conjunction with the Phase I Source Monitoring Program to estimate employee exposure above the retort. Employee

exposure can be corrected to account for: 1) distance to the source 2) average wind velocity and direction, and 3) time of exposure and/or level of activity. The addition of these new data to existing literature documenting emissions per square meter of retort surface area will suffice to substantiate surface emission concentrations.

Additional identification of hydrocarbons may be necessary to separate innocuous gases (CH_4 , C_2H_5 , ethanol, etc.) from other gases such as thiophenes, phenols, naphthenes, etc. Thus, emission samples are collected and analyzed and the gases of concern are then separately described by their physical behavior in heat, wind, humidity and as sorbed or condensed chemicals.

5.1.2.2 Oil/Water Separation

During the oil/water separation step, escaping gases may contain NH_3 , H_2S , CO , CO_2 , H_2 and various hydrocarbon vapors or mists. Such emissions will be monitored under the Source Monitoring Program, and the resulting values will be used to determine worker exposure to these gases.

The sludge and tank bottoms from both tanks (emulsion and gravity) used in oil/water separation will contain hydrocarbon sediments, mineral sediments and various water soluble materials in liquid and mist forms, both in solution and suspension. Exposure to workers could occur on an infrequent basis when tanks are drained or cleaned, or when sediment sludge is removed. At such times, protective clothing will be mandatory for workers.

Areawide sampling and analysis around the vent area will determine the ambient concentration of materials of concern. These analyses will assist in making final determinations relative to Phase II monitoring in all areas.

5.1.2.3 Oil Storage and Shipping

The oil storage and shipping process is a tankage operation with routine worker exposure to vents, nozzles and valves which may emit gases, fumes, aerosols and vapors. Any liquid losses (leaks) which are collected in sumps also may provide a constant low level source of gases and mists.

Phase I sampling and analyses under the Source Monitoring Program will identify both the qualities and quantities of gases, aerosols and vapors in the area. This area-wide, low level of exposure need not be corrected for each employee, unless a particularly toxic material is found in the monitoring program. Generally, an employee can be described as incurring some sort of daily exposure to some average level of material from the oil storage/loading area atmosphere.

5.1.2.4 Retort (Sour) Water Treatment

The Health and Safety Monitoring Program in this area will center on those emission points that regularly vent materials to the environment. Steam tanks and pipes in sour water treatment are essentially closed systems with only emergency relief valves as a potential source of contaminated materials. Thus, the only operating equipment source of materials of concern is the vent to atmosphere, releasing the KTI boiler flue gas. This stack will be monitored under the Source Program.

5.1.2.5 Waste Accumulation and Disposal

In order to properly monitor workers health, the wastes involved in the Geokinetics process must be characterized. This will be accomplished in the Source Monitoring Program. At this time, the combined sludges from the oil/water separator facility and the sour water treatment facility will be monitored. Both of these waste streams may contain

suspect materials. The oil/water separation sludge will contain a variety of heavy hydrocarbons, several polar (miscible/soluble) hydrocarbons and dissolved/suspended carbonaceous materials. Emulsifying agents also may occur in this waste stream. In addition to organic materials, heavy metals and their salts may occur in the oil/water separation sludge.

The KTI boiler sludge which enters the waste accumulation tank from the sour water treatment facility will provide occupational hazards similar to the oil/water separation sludge. There will be no detectable surfactants and no volatile elements (Hg) in this waste stream.

The Phase I sampling and analysis (source monitoring) program should identify and quantify the organic and inorganic materials of concern in the waste accumulation area. Area sampling and individual dosimetry will then be conducted for materials of concern, using suitable pumps, filters and absorbent media. After having defined and quantified the prevailing concentrations of materials of concern, each worker can be described as being exposed to an average daily concentration of each material of concern. Depending upon the findings of the sampling and analyses, Geokinetics may develop isopleths of concentration.

5.1.2.6 Ammonia Removal

This operation is essentially a closed cyclic system with few vents, or other potential sources of liquid or gaseous material. Ammonia (NH_3) and sulfur-laden gas are the products of this operation. Although both these products are toxic they are easily detected and do not provide an insidious occupational hazard. During this step, continuous monitoring for NH_3 , CO and H_2S will be conducted. No worker will be intentionally exposed to any environment containing an excess (EPA, MSHA, OSHA defined limits) of either gas. Monitoring for NH_3 , CO and H_2S is an adjunct to good plant operations, but a monitoring and enunciator system may be used to alarm nearby workers and clear the area in the event of a leak or blowout.

5.1.2.7 Sulfur Removal/Recovery

There are no routine equipment sources of occupational hazard associated with this operation. However, there are material sources of occupational hazards, arising from the production of the sulfur cake and from equilibration or pressure vents. Both the water and the elemental sulfur produced by this process will be contaminated with trace amounts of H_2S , COS , mineral salts, Stretford catalyst foaming agent and hydrocarbon sulfur materials. Assuming the efficiency of this desulfurization process is as described, there should be barely detectable traces of hazardous materials except H_2S and COS in either the sulfur cake, the excess water or the water vapor vent.

A brief sampling and analysis program will quantify the concentrations of materials of concern in the desulfurization/sulfur recovery work areas. In the event a measurable concentration is discovered, workers in these areas should be described as being exposed to the average eight-hour concentration of the material of concern. Workers loading sulfur cake should wear protective masks and clothing.

5.1.2.8 Incinerator

The stack area will be sampled and analyzed under the Source Monitoring Program. Area measurements will be made to determine ambient concentrations (employee exposure) at ground level. The source monitoring system will provide ample data to corroborate the health concerns in this area. Ambient concentrations can be corrected for meteorologic factors and should be corrected for stack operating temperatures. Workers handling stack ash or flue scrapings will wear protective masks and clothing.

5.1.2.9 Power Generation

The steam power generation system is fired by a mixture of natural gas and treated retort gas. Health monitoring as described for the incinerator will be implemented in this area.

5.1.3 Health Monitoring During Reclamation

Reclamation assumes that an abandoned retort is being cooled (passively), salvageable materials are being dismantled and removed, and the retort surface is being recontoured and revegetated. The retort area will remain warm and escaping gases may be detectable above the ground.

The trace amounts of escaping gases and particulates from reclamation pose the only occupational health hazard in this area. Dust control methods are recommended to protect equipment operators in the area. Area monitoring supplemented by Phase I source monitoring data for fugitive emissions will be used to develop exposure data needed to describe workers involved in restoration.

5.2 Medical Surveillance Monitoring

A physical examination and clinical evaluation will be performed for each employee at the time of his initial hiring. This medical evaluation includes a record of the individual's work history (e.g., previous exposures to mine dusts), as well as tests of sight and hearing, pulmonary function, chest radiography, and laboratory analyses of blood and urine. The results of the examination are supplemented by questionnaires relative to occupational and non-occupational injury or illness, past noise exposure, smoking and alcohol use, etc. which assist the examining physician in determining the individual's work capabilities relative to the potential risks and stresses of the specific job to be performed.

The physical/clinical evaluation is encoded using a series of numeric codes on special data sheets which are readily entered into the computer. Each employee is identified by a unique number to maintain confidentiality. The employee health data base is thus initiated with this physical/clinical information set which becomes a part of the health information system.

The industrial hygiene monitoring program outlined in Section 5.1 allows the occupational health program to accumulate representative data describing the exposure of each worker to significant compounds and agents in the work place. The monitoring program data are entered into the employee's computerized health data base to provide an acceptable and valid compilation of employee health records and occupational health data.

The current "right to know" laws can be implemented by simply extracting an employee's coded data base and translating all numerically coded data into a meaningful description of past medical history, current exposure and risk assessment. Such data also may be used to reassign employees to other occupations, or even in the initial assignment of any employee to certain occupations. The computerized records, if supplemented by the findings of a licensed physician, can be legal documentation of health examinations and reassessment of occupational hazards.

Periodic physical/clinical evaluations of employee's health will be conducted, including pulmonary function and specialized tests as they are applicable to specific exposure risks (e.g., audiometry for noise-exposed employees). Data from these examinations also are encoded into the employee's computerized data base.

The health records thus established, including the initial examinations, job exposure information, occupational and non-occupational injury or illness, and periodic medical surveillance, constitute a

worker registry. These data, when developed and retained over sufficient periods of time, provide an information base whereby the factors pertaining to risk and health effects can be recorded and studied.

This computerized data base is readily transferable to a "perpetual" health monitoring system (such as the U.S. Public Health Service or a private health care foundation) to be retained in an occupational health data bank.

5.3 Medical Assistance to Support Health Monitoring

The health monitoring program will be conducted under the supervision of a trained industrial hygienist or physician employed on a contract or part-time basis. This individual will be thoroughly familiar with the various health concerns and job hazards which may exist in the operational facility. Health monitoring data will be input to the computer by a data entry technician employed at the site. Adequate medical facilities and personnel will be provided to administer first-aid for treatment of minor injuries and to meet emergency response requirements.

Procedures for the transport of emergency ill or injured employees will be established well in advance of construction activities. Safety and educational programs will be conducted by trained safety personnel.

5.4 Premanufacture Notification/Toxicological Testing

The Toxic Substance Control Act (TSCA) imposes testing requirements and other substantial regulatory requirements on persons who manufacture or process chemical substances or mixtures which present or may present an unreasonable risk of injury to health or the environment. It also requires testing where information is insufficient to assess the effects of use of the chemical, where the substance is to be produced

in substantial quantities, and where it may reasonably be anticipated that there will be extensive environmental or human exposure.

Of interest to the Seep Ridge Project Health Monitoring Program is that certain shale oil products are being defined by EPA as new chemical substances subject to premanufacture testing for health and environmental effects. The test results and a premanufacture notification (PMN) must be provided to EPA at least 90 days prior to manufacturing or processing of such new chemical substances.

In light of this, Geokinetics has been in contact with SFC, EPA and Utah regulatory personnel to delineate the TSCA PMN approval process procedures, testing and submittal requirements, and other permit-related data needs. Thus, potential testing requirements for Geokinetics' shale oil products are being identified. Brief descriptions of accepted procedures and methodologies will be developed. A milestone schedule that shows the key TSCA PMN testing steps in relation to the Seep Ridge project development timetable will be provided.

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